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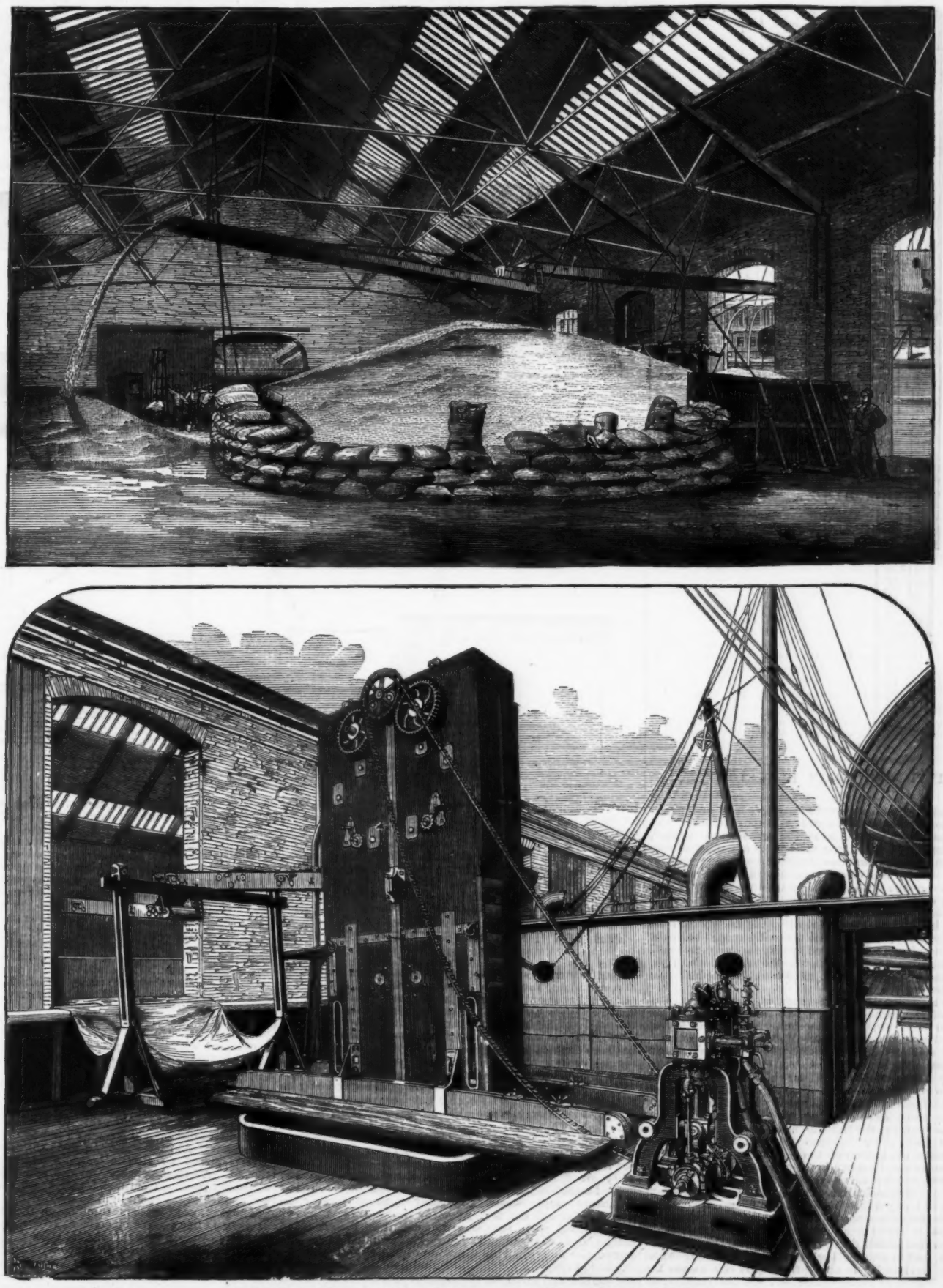
POULSOM'S GRAIN ELEVATOR

THE elevator we illustrate is the invention of Mr. W. Poulsom, of Liverpool, and was first brought into use at the beginning of 1880, during which year it was improved by Captain J. Stanhope, of Liverpool. The advantages claimed for the arrangement are numerous, and will be referred to hereafter. The machine is portable, being carried on a barge about 60 ft. long, 14 ft. beam, and 6 ft. deep, and when not in use it is stored away under hatches. When required for work it is raised from the barge by the ship's gear and winch, and lowered into the hatchway, the whole being secured on two beams placed over the combings. A small engine with cylinders 6 in. in diameter and 8 in. stroke is also laid on deck, and coupled to the driving



POULSOM'S IMPROVED GRAIN ELEVATOR

wheel of the elevator by means of detachable driving chains. The steam is conveyed to the engine by flexible steam hose from the boiler on the barge lying outside. When necessary the elevator barge can lie outside other barges for the convenience of the steamer, the grain being discharged at the same time.

The apparatus consists of two long wooden trunks, each being provided with a leg which acts telescopically and automatically, lowering itself into the grain according to requirements. By this means the grain is taken from each side of the ship at the same time, the screw-shaft tunnel or fore-and-aft bulkhead forming no obstacle. The grain is delivered from a stationary chute near the top of the machine, and conveyed ashore by means of endless portable conveyer belts to a distance of 100 feet, the whole being driven by small engine referred to.

The grain may also be delivered over the side into small craft; the weighing when necessary being done on the ship's deck. A large hopper is supplied by means of a short conveyer, the grain being drawn therefrom into scales placed underneath.

The whole apparatus can be fixed ready for work in less than an hour, and does not require any further raising or lowering until taken out. It will discharge grain at the rate of 60 tons an hour at commencement, but, as is well known,

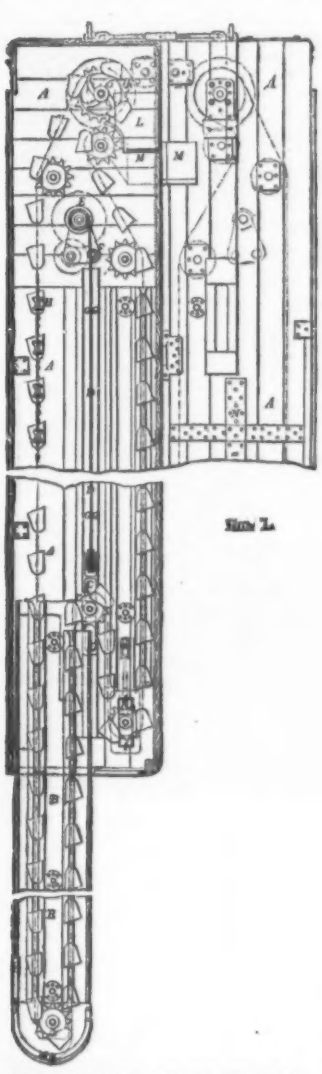


Fig. 1.

IMPROVED GRAIN ELEVATOR.

this is reduced when trimming in the ship's hold and cleaning up, bringing the average down to 50 tons an hour.

A very important advantage in the arrangement is that, being secured to the hatch, the machine is not affected with the listing of the ship, and can therefore be kept at work at any angle. Either half of the machine can be worked separately, and thus the vessel can be brought upright by working one leg only.

These machines are now used extensively in the port of Liverpool, being owned and worked by the Liverpool Grain Elevator Company, Limited, who make it a special business. The quantity of grain discharged by this company, and with the apparatus described, has risen from 21,000 tons in the half year ending June, 1881, to 200,000 tons in the half year ending June, 1883.

Fig. 1 is a sectional elevation showing the internal construction of the machine. The two frames or trunks are constructed of timber, the corners protected with angle iron, and the bodies stiffened with rolled steel plates. Wrought iron stays are added to strengthen the whole framework. Each frame, A A, is provided with a leg, B, which is suspended on a pair of frames, C, and is raised by means of two steel wire ropes, D, and the barrel, E, the latter being worked with internal gear from outside by placing a catch wheel and crane handle on the shaft, F. By raising the pawl when working, the full weight of the leg is allowed to rest on the grain, and it will then automatically lower itself until it reaches the bottom of the ship, having a traverse of 21 ft. The frames, C, move in the channels, G, constructed of angle iron, and it is this novel arrangement which enables the leg to act telescopically. The buckets are made from sheet steel 11 in. by 4¼ in. by 5¼ in. deep, and are secured by the ends between a pair of detachable chains, a special flanged link, H, being placed at every fourth link. A chain race is provided inside, lined with steel plate, for the chain to work in, and to prevent the chain from swinging when the ship or elevator leg is not upright. By this means the buckets are kept in a true course and are prevented from fouling each other. Tension gear at I will take up the slack chain. Special wheels are used to suit the chain. The shafts are of steel, having bell-metal bearings. Grates are fitted to the bottom of the legs J, made from steel of a V section, to prevent pieces of timber or other material from getting into the machine. The grain is raised by the buckets and delivered over the top wheels, K, and into the hopper, L, coming out of the chute or opening, M. The grain then drops on portable conveyers (according to distance required) provided with receiving hoppers, and is thus conveyed into the adjoining sheds, and delivered in large heaps of from 200 to 1,000 tons, as shown in our top illustration on first page.

Fig. 3 is a section showing the arrangements of traveling band; from this figure it will be seen that it is moved between the inclined and free running rollers, placed at intervals on each side of the trough, and so spaced as to allow the belt to receive and to retain the grain. In retiring, the belt lies flat on the set of horizontal carrying rollers underneath. Fig. 3 is a perspective view of a conveyer. The belting is made of cotton. The conveyers are connected to the machine by means of a swivel device, which enables them to be placed at considerable angles to the ship.

The bottom illustration on first page shows the general appearance of elevator on deck, when fixed with small engine coupled to drive the chain wheel. The spur gear connecting the two trunks is shown at the head of the machine. Fig. 4 shows sectional positions of elevator barge, steamer, and shed, with general appearance of elevator, small engine, etc., when at work delivering grain into a shed. The dotted lines show the method of weighing on deck and shooting grain in bulk into small craft lying outside, or into sacks for storing. The long plates, N, fitted outside the trunks have holes drilled and tapped in them placed 8 in. apart, so that the machine can be lowered into the hatch according to the quantity of grain in the ship, and secured to the beams with angle brackets.

The length of an elevator when closed is 28 ft., and each half weighs 34½ cwt. It will unload a steamer 40 ft. deep, and deliver the grain on the quay, in a pile 15 ft. high, to any distance up to 100 ft.

The manufacturers are Messrs. S. S. Stott & Co., of

Fig. 3.

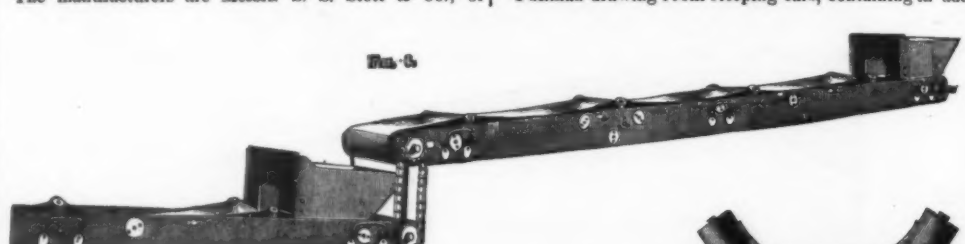
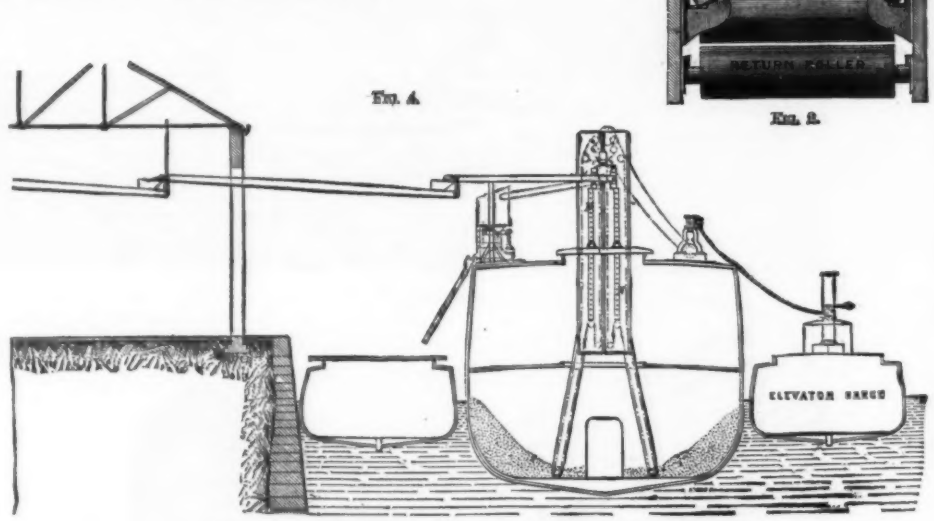


Fig. 2.

Fig. 4.



THE POULSOM GRAIN ELEVATOR.

Laneside Foundry, Haslingden, near Manchester, who have for some years made elevators their specialty. The same firm has recently built one with steel buckets, and of a capacity of 120 tons an hour, but about half the usual size; this is for the large grain warehouses at Birkenhead, owned by the Mersey Docks and Harbor Board. Messrs. Stott & Co. are also adapting the same principle to a number of oxide elevators for the gas works of Birmingham, Lincoln, etc., and also for other purposes.—*Engineering.*

THE NEW YORK, WEST SHORE & BUFFALO EQUIPMENT.

THE locomotives of this company have been especially designed for the various services for which they are required, and may be classed among the finest specimens of locomotive construction in the United States. Owing to the excellent road-bed and the heavy section of rail used, also the great strength of the iron bridges and trestle work, this company has been enabled to build exceptionally heavy locomotives for its various classes of traffic. The passenger engines burn anthracite coal, and are designed to haul passenger trains, consisting of from 10 to 15 coaches, at a speed of from 50 to 60 miles an hour. Nothing has been omitted in the design of these engines to render them amply strong for this work. They are equipped with all the modern improvements known to engineering science, in order to make them as economical as possible, and to avoid those annoyances to the traveling public which are so common on most roads. They are fitted with the Westinghouse air brake, and special attention has been paid to the design of the boilers to insure ample steaming capacity without forcing the draught through the fire, so as to throw cinders. They are provided with special arrangements in the fire and smoke boxes to consume all the gases generated in the fire boxes, also to prevent the throwing of cinders. The smoke stack is of special construction to facilitate the steaming of the engine, and avoid the throwing of sparks. The tenders are of unusually large capacity, both for coal and water, to enable them to run long distances without stopping. The trucks are equipped with 42-inch Allen paper wheels, to insure quiet and easy running. All the material used in the construction of engines and tenders is of the very best quality, test strips being cut from each separate piece of material and tested before any of it is allowed to be used in construction. This is done in order to avoid a failure of any portion. The engines are very plain in exterior finish, the old-fashioned decorations having been omitted entirely, so that they present a very massive appearance. The freight engines constructed for this company are certainly the most powerful engines in the Eastern States, weighing 53 tons, and capable of hauling a train of 70 or 80 loaded cars over any portion of the road. Special attention has been given in designing these engines to insure the utmost economy in working. The heating surface of the boiler has been increased to give ample steaming capacity, and the bearing surfaces of all the working parts have been enlarged to insure durability. The tenders of these engines are of the same construction as those used on passenger engines. The freight engines for ordinary service are fitted with improved designs of steam brakes, while those used for express freight, fruit, and stock trains are equipped with an automatic air brake. The switch engines constructed for this company are very powerful, having been designed with special reference to the rapid handling of trains in the various yards where they are used. They are unusually smart, and are capable of handling any train that a freight engine may bring in.

The entire engine passenger equipment of this company has been built by the Pullman Palace Car Company, at their works in Pullman and Detroit. In addition to the cars owned and operated by the company, the Pullman Company is running sleeping and parlor cars on all through trains. The cars in service are classified as follows:

First-class passenger cars, summer cars, dining cars, combination smoking and buffet cars, combination smoking and baggage cars, combination mail and baggage cars, combination baggage and express cars.

The Pullman cars are classified as follows:

Pullman drawing-room sleeping cars, containing in addition to the regular sections a state-room, smoking-room, and a buffet; the Pullman sleeping cars, containing smoking-room and a buffet; the Pullman sleeping cars, containing the buffet; the Pullman parlor car, containing the buffet.

The West Shore passenger cars are mounted on four wheel trucks, with 42-inch Allen paper car wheels and steel tires. They are supplied with the combination Janney & Miller platforms, with draw-bars and buffers, with the Westinghouse automatic air-brake, as well as the Pintsch gas apparatus, and are heated by steam under low pressure.

The passenger cars are large, roomy, and comfortable. The first-class cars are finished on the interior in mahogany, with maple floors. Seats are large, comfortable, and upholstered in plush. The windows in all passenger cars are much larger than they are usually made. The summer cars are finished on the interior in ash and cherry, with seats upholstered in rattan.

The combination smoking and baggage cars are finished on the interior in figured oak. The passenger compartment is provided with revolving chairs, upholstered in leather.

The baggage, mail, and express cars are well adapted for their particular service.

All these cars are of uniform section, and painted on the outside in a rich dark olive color, making in effect a very handsome appearing train.

The Pullman cars run on this line are made after the latest and best designs. They are all finished on the inside in mahogany. At each seat or berth in the sleepers or parlor cars is placed an electric button to summon the porter of the car. All these cars are provided with buffets, in charge of the car porters, from which passengers can be supplied with coffee or tea and a light lunch.

The ceilings of all cars running on the West Shore are decorated after designs by eminent artists, employed by the Pullman Company for this special work.

The buffet cars referred to above were built expressly for express train service on the New York, West Shore & Buffalo Railway, and are so called because they are provided with a "buffet" or sideboard which occupies a space eight feet by

three and a half, situated immediately in front of the smoking room. The front of this cozy inclosure, facing the drawing-room, is plate-glass, partly screened by rich drapery. The finish of the "buffet," in both wood-work and marquetry, corresponds with the interior of the car, and the effect of the design is highly pleasing, suggesting, as it does, in convenience and luxuriousness an elegant sideboard in a richly-appointed mansion. The perspective, looking from the main saloon, is one of harmonizing effect. From this elegant sideboard, which, in addition to the necessary fixtures in miniature, contains shelves for a circulating library, will be served to such as may desire it a delicate luncheon, such as a cup of French coffee, tea, a sandwich, or a cup of bouillon. This innovation, the conception of which originated with Mr. George M. Pullman during a recent tour in Italy, is not designed to encroach upon the dining-car, the hotel-car, or the eating-station, but, on the contrary, is intended to relieve slight hunger between meals, or, as it may often happen, to afford a delicacy to such passengers as may be too ill to leave the car. The buffet cars on the West Shore route have proved a popular success.

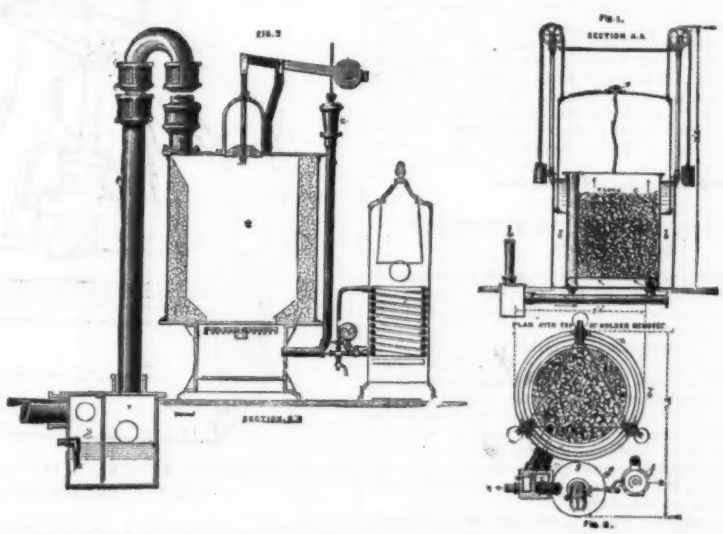
One-third of the entire road is level. The prevailing maximum grade is 20 feet to the mile going east and 30 feet to the mile going west. Eighty per cent. of the entire road is a straight line, and the maximum curves are four degrees, and only on 28 miles does the curvature exceed two degrees. The double track is laid with 67 pound steel rails—the heaviest yet used continuously in the State of New York. Easy grades, light curves, iron bridges, solid masonry, and the most approved methods of construction add to the attraction of the West Shore route.

The station houses erected by the New York, West Shore & Buffalo Railway Company are from original drawings prepared by the company's architect. They are designed not only to promote efficient service at stations, but with regard to the comfort and convenience of passengers. The more pretentious stations at the New York terminus, at Kingston, Albany, Utica, Syracuse, and Buffalo will surpass, when finished, in completeness and artistic decoration, any series of railway stations ever erected by a single company.—*Railway Review.*

GAS ENGINE PRODUCER.

SEVERAL Otto engines are now working regularly with Mr. Dowson's cheap gas, but finding that many users of gas engines have little ground space to spare for gas-making apparatus, he has just introduced a complete set of specially compact plant. This requires an area of only 10 ft. by 7 ft. for a gas engine indicating over 40 horse power, and a very slight increase suffices for double that power. The plant is shown in Figs. 1, 2, and 3, and consists of a small gasholder, *a*, and tank, *b*, with a scrubber, *c*, placed inside the tank. The scrubber is filled with coke or other suitable material, and the gas is passed through this before it reaches the holder. On the top of the holder is an escape valve, *d*, to let off gas in the open air or up a waste pipe when the holder is full and when the make of gas exceeds the consumption. This, however, is not much used, for there is also a regulator, *e*, on the generator—Fig. 3—which, within certain limits, governs the production of gas by the rise or fall of the holder, and this not only avoids waste of fuel, but renders the storage of much gas unnecessary. A sectional view of the gas making apparatus is shown in Fig. 3, and this consists of a steam superheater, F, a gas generator, G, an outlet pipe, H, and a siphon box, I. The gas is made by forcing a continuous current of steam and air through a fire in the generator, so that the high temperature of the fuel is maintained while a constant volume of steam is decomposed. The oxygen of the air and steam combine with the carbon and produce carbonic oxide, which is rendered more inflammable and explosive by the hydrogen from the steam. The gas is of course largely diluted with nitrogen, and for this reason a special type of gas engine is required, which we illustrate above. The total cost of the gas, including wages, etc., and allowing for the increased volume of this gas required to develop the same power as coal gas, is equal to coal gas at 1s. 3d. to 1s. 6d. per 1000 cubic feet, according to the scale of working. Messrs. Crossley Brothers have been using the Dowson gas for some of their ordinary 16 H. P. engines for several months past at their new works, and careful trials have shown, we are told, that with these the fuel consumption is 1·4 lb. per indicated horse-power per hour. They also find that the wages of the fireman for several gas generators are not more than for a set of steam boilers, and that as the gas can be conveyed to any part of the works without condensation, separate engines can be used for different lines of shafting, and this not only effects a saving in the cost of shafting, but any department working overtime can have its engine supplied with gas from a single generator.

It may be mentioned that the results obtained with this gas have led Messrs. Crossley to construct a special double-cylinder engine to indicate 70 H. P. with the Dowson gas, and this has just been fitted up for regular work.—*The Engineer.*



DOWSON GAS ENGINE AND PRODUCING PLANT.

DETERMINATION OF CARBON IN IRON AND STEEL—NEW METHOD.

By N. B. WOOD, Member of the Civil Engineers' Club,* of Cleveland. [Read May 8, 1888.]

IN the composition of steel and iron nothing has been studied with greater interest or industry than carbon.

In their composition nothing so materially affects their quality and fits or unfits them for the purposes of the engineer.

The quantity which is found in a given specimen affects its physical character greatly, but its state of combination affects it to a much greater extent.

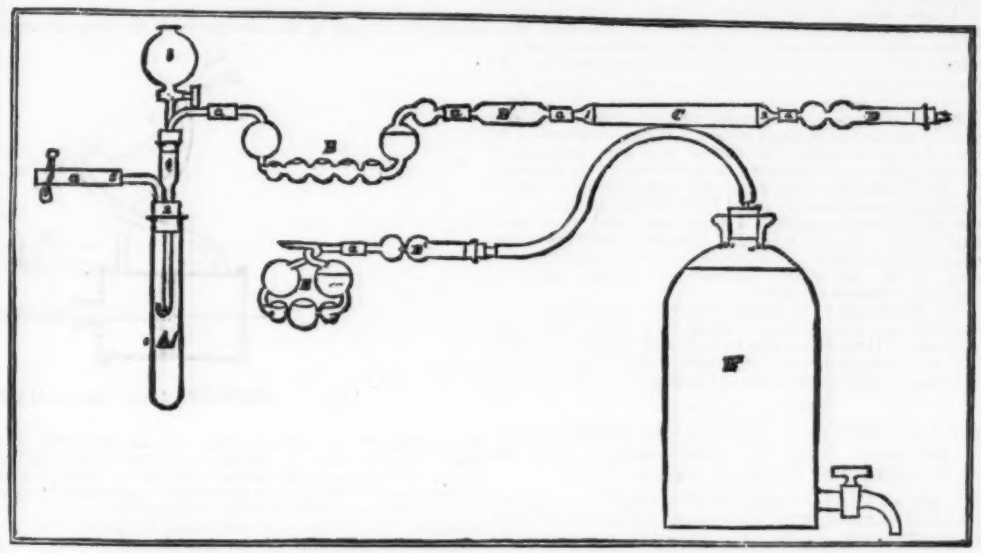
Thus we find that a soft gray cast iron has comparatively large qualities of carbon (from three to five per cent.), only a little of which is combined, while a white or chilled cast iron, which to chill well should have a little less, say three per cent., but may be from the same pig metal, has most of its carbon in a state of combination.

Steel, theoretically, should have all of its carbon in the combined state, but as no steel which we have yet examined has had this condition of things, and as the more nearly we find all the carbon combined the better we find the quality of steel, we concluded that the theoretical steel is perfection, and that one containing large percentages of uncombined carbon is comparatively poor. This being the case, it is evident that a method by which carbon, in both of its states in steel and iron, can be determined with certainty is a thing much to be desired.

Methods have not been wanting; in fact, they are numerous, but they are either extremely tedious or quite unreliable. In connection with these remarks, it may be well to quote from an excellent work on this subject by L. L. De Koninck, in which he says: "In the analyses in which we are engaged it is advisable always to pursue the same method of operation, for in general different methods give different results." Mallet, in his notes on this subject, says: "The methods employed or proposed, and emanating from some of the greatest among chemists, still leave much to be desired."

When metallic iron, in any of its forms, is treated with a non-oxidizing acid and water, it is oxidized at the expense of the oxygen of the water. Hydrogen is liberated, which would be pure if no impurities existed in the iron, or otherwise. But all iron contains more or less carbon, sulphur, phosphorus, etc., combined as carbides, sulphides, and phosphides, and these compounds are decomposed by the stronger acids, yielding their carbon, sulphur and phosphorus to unite with the hydrogen, which is liberated at the same instant, and which in this case plays the part of a metal, combining to form carbide, sulphide, and phosphide of hydrogen. These compounds have a peculiar and extremely disagreeable odor, not unlike that of a certain little animal whose name is so much abhorred that it is seldom spoken, on account of its (the animal's) peculiar method of using its odor as a means of defense.

If we burn the escaping gas (from the iron, not the animal), we shall have, in the open air, water, carbonic acid, sulphurous acid, phosphorus acid, and perhaps some phosphoric acid. If we burn them in a tube with oxygen, we shall have nearly the same result, and could collect them and weigh them, but the result would be of no value unless they were separated, because of the uncertainty of the original mixture. To effect this separation and to determine in one operation the uncombined and combined carbon and sulphur, more particularly the two former, is the object of the method and apparatus which this paper is intended to describe.



APPARATUS FOR THE DETERMINATION OF CARBON IN IRON AND STEEL.

The apparatus is best understood by referring to the illustration. A, B, B', C, D, E, E', and F are the main parts of the apparatus used, the numerals referring to details belonging to them. A is the tube in which the iron is dissolved in acid, and the hydrogen liberated; B is a tube calculated to wash the gas and free it from sulphur and phosphorus; B' is a tube filled with chloride of calcium, to dry the gas before entering the combustion tube, otherwise it might be broken by water coming in contact with the red-hot glass; C is the combustion tube, in which the gas is converted into water and carbonic acid; D is a chloride of calcium tube for absorbing the water; and E is a Liebig potash bulb for absorbing the carbonic acid. F is an aspirator, which is calculated to draw a current of air through the entire apparatus at the close of the operation, to remove whatever gas may remain in the tube after action has ceased in the tube, A. The tube, A, consists of the test tube, No. 1, about five inches long by about three-quarters of an inch in diameter, fitted with a cork, 2, of rubber, perforated with three holes, one for the accommodation of the thistle tube, 3, one for the drying tube, 4, and one for the air tube, 5. The thistle tube, 3, is fitted with a stop-cock or other device by which its contents may be allowed to drop slowly into the tube, 1. It is turned up at the lower extremity, in order that no gas may escape through it into the air.

The tube, 4, is filled with asbestos or pumice stone, saturated with concentrated sulphuric acid to prevent the fine spray from the action of the acid on the iron being carried over into the tube, B. The tube, 5, is intended to allow air to enter at the end of the operation when the aspirator has been connected. It runs to the bottom of the tube, 1, so as to carry away any remaining gas with its current of air. It is provided with a stop or clip cock on the piece of rubber tubing, *a*, which can be opened at any time the operator thinks necessary. The tube, B, is complete within itself, being blown out of a single piece of glass, and is designed with special reference to completely washing and absorbing from the gas all sulphur. For this purpose it has the large end bulbs sufficiently large to accommodate all the fluid which might be forced out of the remainder of the tube by too rapid evolution of gas; the successive bulbs allow the gas to proceed, bubble by bubble, until forced out at the further end. The number is largely in excess of the actual needs of the operation, the black deposit of sulphide being seldom found beyond the first horizontal bulb in ordinary steel. This tube is partly filled with an alkaline solution of lead, made by dissolving freshly precipitated oxide of lead in an excess of caustic potash. Acetate of lead must be avoided in this solution, as it might be carried into the combustion tube with the gas and produce carbonic acid by its combustion. It is possible that an acid solution of lead, arsenic, or silver would be better suited for this purpose. The tube, C, is made of glass, which need not be of the infusible kind generally used for combustion tubes, as it is only intended to bear a dull red heat. One end of a tube of from three-eighths to one-half inch in diameter is first drawn out to the size which will just fit the rubber tubing, *a*, used to make the joints; it is then filled about half an inch at 1, with asbestos, then filled six inches or more with lead chromate mixed with about one-eighth of its weight of potassium bichromate, all fused and finely granulated, not too fine, or it will stop the flow of gas (according to Fresenius, page 621, §177); a small plug of asbestos, 2, is put on top of the filling in the tube, and the other end drawn out. Any suitable means of keeping this tube at a uniform red heat will do, but of course the usual combustion furnace and tubes are all the better. In the illustration we have shown the tube heated by three Bunsen burners with spread flames. I have used a common gasoline stove with excellent results. The whole apparatus should incline

* It is proper to state that the author, in preliminary remarks, stated that although the title claimed the process new, it might be old, but was new to him. And that there might be some doubt about all of the combined carbon uniting with the hydrogen to form a permanent gas, but that it was his opinion that the process gave valuable data by which to arrive at the quality of steel, and that it was of as much or more importance to know the amount of carbon in the form capable of being volatilized by the action of acids, as to know how much existed in the graphitic state.

slightly toward F, from the forward end of C. The remainder of the apparatus has been sufficiently described. The operation is as follows: A quantity of the sample is weighed out. I use ten grains, which with a balance sensitive to $\frac{1}{1000}$ of a grain will give $\frac{1}{10000}$ part as weighable carbon; larger quantities take much longer time, and there would be danger of not oxidizing all the gas. However, one gramme might be used.

It is put into the tube, A, and the whole apparatus connected by the rubber tubes, *a*. Everything depends on these joints being perfect—to test them we turn the cock of the aspirator, and if only a few drops of water fall into the beaker we may consider every joint tight. Next bring the tube, *c*, to a red heat, and then turn the cock in the tube, 3 A, so as to allow the acid to flow in drop by drop. Nothing can be done now but to wait until action in the tube, A, has ceased, which we can readily perceive when no more bubbles pass through B; when this happens the stop-cock in A 3 is closed and the clip cock in A 5 is opened, and a current of air is allowed to go through the entire apparatus until the bubbles begin to pass freely through E into F; the bulb, E, is now taken off and weighed, it having been carefully weighed before the operation began, and the difference will be the weight of carbonic acid absorbed; this multiplied by 0·27273 will give the amount of carbon of combination. A black residue is now found in tube, A, which may be filtered through an asbetos filter or plug, dried at 250° to 300° Fahrenheit, weighed, incinerated, weighed again, the difference being the uncombined carbon. If greater accuracy is needed, this residue must be burned in a combustion-tube and the carbonic acid weighed, as in the case of the combined carbon, according to some of the well-known methods. The sulphur *may* be determined from the black residue in the tube, B, but its quantity is rather small, and would perhaps be better done by a separate operation, using the same apparatus as far as B'. The sulphide in B is converted by some of the well-known methods into sulphate, and the amount of sulphur calculated.

The advantages of this method seem to be numerous. It requires but one operation where three were originally necessary. It takes less time by half, and it needs no extra care in the preparation of the sample, which in some of the processes is very troublesome and tedious.

ON EXPLOSIONS OF VESSELS CONTAINING COMPRESSED OXYGEN, COMPRESSED AIR, OR COMPRESSED NITROUS OXIDE.

A FEW weeks ago we published an account of a curious explosion of a boiler filled with compressed air, which was employed to work the machinery employed in hauling coal, at Ryhope Collieries, Sunderland, on the 1st March last. It appears as if the whole apparatus concerned were saturated with oil and coal dust, and to the combustion of these materials in the compressed air the explosion was or rather is due. There is nothing in the description to lead one to believe that the iron, which was doubtless rusted, corroded, and dull, actually took fire, but this might have happened, and the heat and pressure would have been rapidly and dangerously increased. An interesting description of the characteristics of such an explosion, when the iron or steel of the vessel begins to burn, was given about nineteen years ago by Professor Frankland, F.R.S., in a short account of the combustion of iron in compressed oxygen. He says that while oxygen was being compressed into a Natterer's apparatus, recently supplied to the Royal Institution from Vienna, an accident occurred, which deserves to be placed on record owing to the interesting relation of iron to highly-compressed oxygen revealed by it. The accident occurred in the following manner: Oxygen was liberated from pure chlorate of potash, heated in a Florence flask, and was collected in a floating bell-gasholder, whence it was drawn through a flexible tube, and pumped into a strong wrought iron receiver of 0·62 liter capacity, and weighing 2·775 kilogs. When about 25 atmospheres of oxygen had been introduced into the receiver, a sharp explosion occurred, followed by a shower of brilliant sparks, which lasted for several seconds. On examining the apparatus it was found that the union joint connecting the pump with the receiver had given way, allowing the compressed gas to escape from the latter. The pump head containing the valve was slightly scorched internally. The steel tube connecting this head with the receiver was very hot, and had evidently been in a state of active combustion, as it was coated internally with a layer of fused oxide of iron (magnetite ?), while its bore had increased to at least three times its original size, and in two places the tube was even perforated. The receiver was also heated, although not to such an extent as to be unbearable by the hand. On examining its interior it was found that the combustion had been propagated to the steel cap, the narrow passage in which was hollowed out into a capacious chamber, while the steel screw valve had been completely consumed. The combustion had not, however, stopped here, but, extending into the receiver itself, had seized upon the internal walls of the latter and covered them with fused globules of magnetic oxide of iron, and there can scarcely be a doubt that, had the union joint not given way and thus furnished an outlet for the compressed oxygen, the latter would in a few seconds more have converted the receiver into a most formidable shell, the almost inevitable explosion of which would have scattered fragments of intensely ignited iron in all directions.

Regarding the primary cause of this explosion, there can scarcely be two opinions. The piston and valves were lubricated with olive oil, and the latter, becoming ignited by the heat of the compressed gas, had communicated its combustion to the steel and iron of the apparatus. Although pump and receiver were not artificially cooled, yet this circumstance did not in all probability contribute materially to the ignition, because the oxygen was very slowly pumped into the receiver, the operation having to be frequently interrupted, to wait for the necessary quantity of gas which was being contemporaneously generated. Moreover, it had been found immediately before the explosion that the receiver was quite cold, and the head of the pump only just perceptibly warm. A few days previously sixty atmospheres of oxygen had been with impunity rapidly pumped into the same receiver, and equally without any external refrigeration. How, then, is this difference of result to be accounted for? The answer to this question is not difficult, when an apparently trivial alteration in the condition of the apparatus in the two operations is known. In the directions for the use of Natterer's apparatus, contained in the article "Kohlensaure"—*Handworterbuch der Chemie*, vol. iv.—the writer states that before the pumping begins, the space between the piston and the valve should be filled up with oil, so as to prevent the retention of any gas between the piston and the valve when the former in compression is pushed to the extreme limits of its stroke. Any gas so remaining in such space—schadlicher Raum—expands again on the return of the piston, and thus causes, if not an actual loss of power, at least a considerable retardation in the compressing process. In the operation above described, in which sixty atmospheres were compressed with impunity into the receiver, the directions of the *Handwoerterbuch* were omitted to be taken; while in the subsequent experiment, in which ignition occurred, a layer of olive oil about 0·1 in. in thickness was poured upon the piston, so as to exactly fill the space above mentioned.

Now a careful examination of the burnt parts of this apparatus left no doubt that the combustion began in the space between the piston and the valve, and that it was the layer of oil which first became ignited. The compression of oxygen to one twenty-fifth of its volume should, according to thermo chemical laws, raise the temperature of the oxygen to upward of 2000 deg. C., but after making due allowance for the loss of heat to surrounding surfaces, there still remains a temperature sufficiently high for the ignition of oil under favorable circumstances. If the oil be spread in a thin film upon the surface of a mass of metal, the rapid absorption of heat by the latter prevents the temperature of the oil rising to its igniting point; but, in the form of a layer, 0·1 of an inch in thickness, no such rapid refrigeration can occur, and the surface of the oil in contact with the gas may become ignited by the rapid communication to it of the high temperature of the compressed oxygen. This should serve to caution those who may be disposed to use combustible lubricants in the compression of oxygen or nitrous oxide. If ignition of the oil occur at high pressure, it will assuredly be communicated to the iron of the receiver, which evidently burns in oxygen compressed twenty-five times, *with at least the same facility as tissue paper in atmospheric air*, the condition of the various parts of the apparatus, after the explosion, leading to the conclusion that the combustion from the beginning to the end occupied only a short time, probably not more than three or four seconds. The risk attending the compression of oxygen and nitrous oxide may be avoided by the employment of non-combustible lubricants, soft soap appearing to be the material best suited.

The facility with which a mass of iron thus becomes ignited, and the rapidity with which it burns in oxygen, at high pressures, suggests the possibility of employing shells of wrought or cast iron charged with compressed oxygen for warlike purposes. The interior of such a shell would scarcely be more difficult to ignite than gunpowder, and once ignited, the pressure of the inclosed oxygen would, notwithstanding its absorption, be for some time augmented by the intense heat, while the walls of the shell would become thinner until they finally burst into fragments of burning and semi-molten iron. Andrews' calculations show that 780 cubic inches of oxygen in combustion with iron would evolve sufficient heat to raise 1 lb. of cast iron to its melting point. This amount of oxygen introduced into the receiver above described would exert a pressure of 20·5 atmospheres; it would require a quantity of oxygen exerting a pressure of 195 atmospheres to raise the whole receiver to the melting point of cast iron. These conditions are not encouraging, for although a less amount of oxygen would suffice for the purpose required, the thickness of the vessel when used as a projectile would doubtless have to be augmented, and little could probably be effected with less than 100 atmospheres of oxygen forced into the shell—a pressure, which, it is to be feared, would prove not only dangerous, but unmanageable.—*The Engineer*.

NEW TYPE OF DISTRIBUTION WITHOUT ECCENTRICS.

MR. DE LAHARPE, an engineer well known in connection with his labor on steam engines, has invented a new mode of distribution without eccentrics which appears to us to be of sufficient interest to make known.

The principle of this system is as follows:

Let us suppose (Fig. 1) a steam cylinder, V, whose slide-valve moves over the plate, A B, inclined parallel with the direction of the adjustment given by the angle, *a*, of the circular diagram. If we cross the conduits that unite the induction and eduction ports with the cylinder, it will only be necessary, in order that distribution shall be effected according to the diagram, to attach the eccentric rod to the pin, C, of the crank, O C. The piston and slide-valve will in such a case, have the same travel.

We believe it useless to dwell upon the inconveniences that the realization of such an arrangement would present in practice. In order to render the idea that we have just offered possible, it is only necessary to connect the pin, C, with the free extremity of a bent lever, D E F, capable of revolving around a fixed point, E, the other extremity, F, actuating the slide-valve through the intermedium of a rod, G F. In this way the travel of the point, F, is reduced at will, and the direction of the motion becomes convenient and permits of the use of ordinary conduits for induction and eduction.

Now, Mr. De Laharpe has remarked that the motion of the slide-valve can be obtained not only from the crank-pin but also from any point whatever of the connecting-rod that may or may not be in the axis of these parts. The dimensions of the distributing mechanism may thus be reduced at will, and the principal pillow-blocks of steam engines be disengaged from any other movable piece than the connecting-rod. We thus obtain the arrangement shown in Fig. 2, and which will be readily understood.

This mechanism, in which the position of the guide-lever, D E F, is *absolutely arbitrary*, is a kinematic transformation of the eccentric, and is equivalent to the latter as regards the effect produced, while at the same time it presents the following differences:

1. The admission being the same, the exhaust occurs later with the arrangement under consideration than with the eccentric; and the lengthening of the period of expansion reaching about one-sixth, there results an increase in the work effected by the steam before its exit from the cylinder. The compression likewise takes place later, this being due to the fact that, through the oscillation of the guide-lever, the size of the angle of adjustment does not remain invariable.

Fig. 4 represents comparative diagrams showing the prolongation of the periods of expansion as compared with the ordinary system, the mean introduction of the steam and the compression being the same. The case has been supposed here of a simple 0·4 expansion. The mean duration of the expansion is 0·435 by the eccentric and 0·505 by the connecting-rod, or 0·161 more, or about a sixth, as we have stated.

2. The opening and closing of the ports is performed more rapidly than with the eccentric.

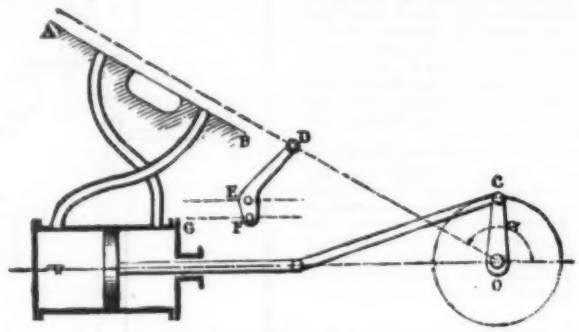


FIG. 1.—PRINCIPLE OF DE LAHARPE'S NEW MODE OF DISTRIBUTION.

3. The admission of steam on the two sides of the piston, as well as the period of expansion, is absolutely equalized.

4. The uncovering of the steam ways by the slide-valve is also absolutely equalized.

We shall advert to this latter point in a moment. Let us remark here that as regards the duration of the various parts and the facility with which they may be adjusted, the arrangement under consideration presents genuine advantages over the eccentric.

It might be feared that the relatively numerous joints in the system would produce modifications in the adjustment, but it is the contrary that is the case. The stresses supported by the joints, C and D (Fig. 1), of the guide-lever are really less than they are with the eccentric; and any wear, even though considerable, that might occur would not perceptibly modify the adjustment or disarrange the motions of the slide-valve in any appreciable way.

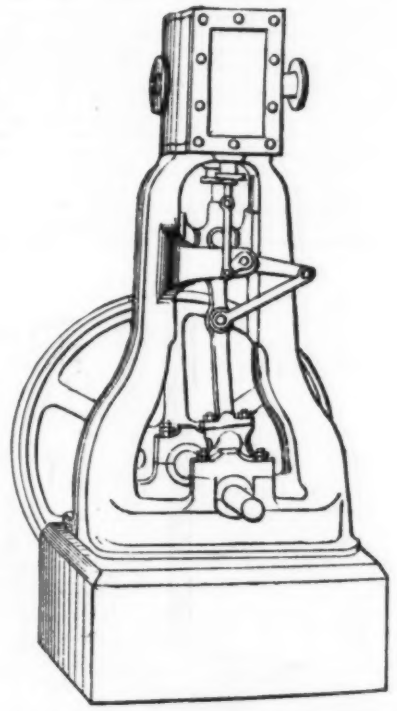


FIG. 5.—UPRIGHT ENGINE WITH DISTRIBUTION WITHOUT ECCENTRICS.

The draughting may be very easily effected. Out of the eight points that it is necessary to consider for a complete revolution (the lead, expansion, exhaust, and compression), seven may always be chosen at will and in advance. The eighth does not as a general thing deviate much from the desired limits, and one may always arrange things so that the difference shall be favorable to a good performance of the engine. Thus (Fig. 2), being given the points *a* and *a'*, the induction being taken equal to 0·5, the compression at 0·72, and the exhaust at 0·9, the perpendiculars, A, B, C, and D, are drawn upon the centers of the chords that unite the corresponding points. With an arbitrary length of rule we determine on these four lines series of points, the most convenient one of which we select in each particular case to pass through it the arc, *b'*. The point, *c'*, is here slightly within the arc, and the exhaust (A V) is thus effected at 0·91 instead of 0·90. The arcs, *a b* and *a' b'* are those of induction.

In order to equalize the uncovering of the steam ways by the slide-valve, it suffices to draw *a' b* equal to and parallel with *b a*, and then join *b b'*. If, through the axis, *g*, of the

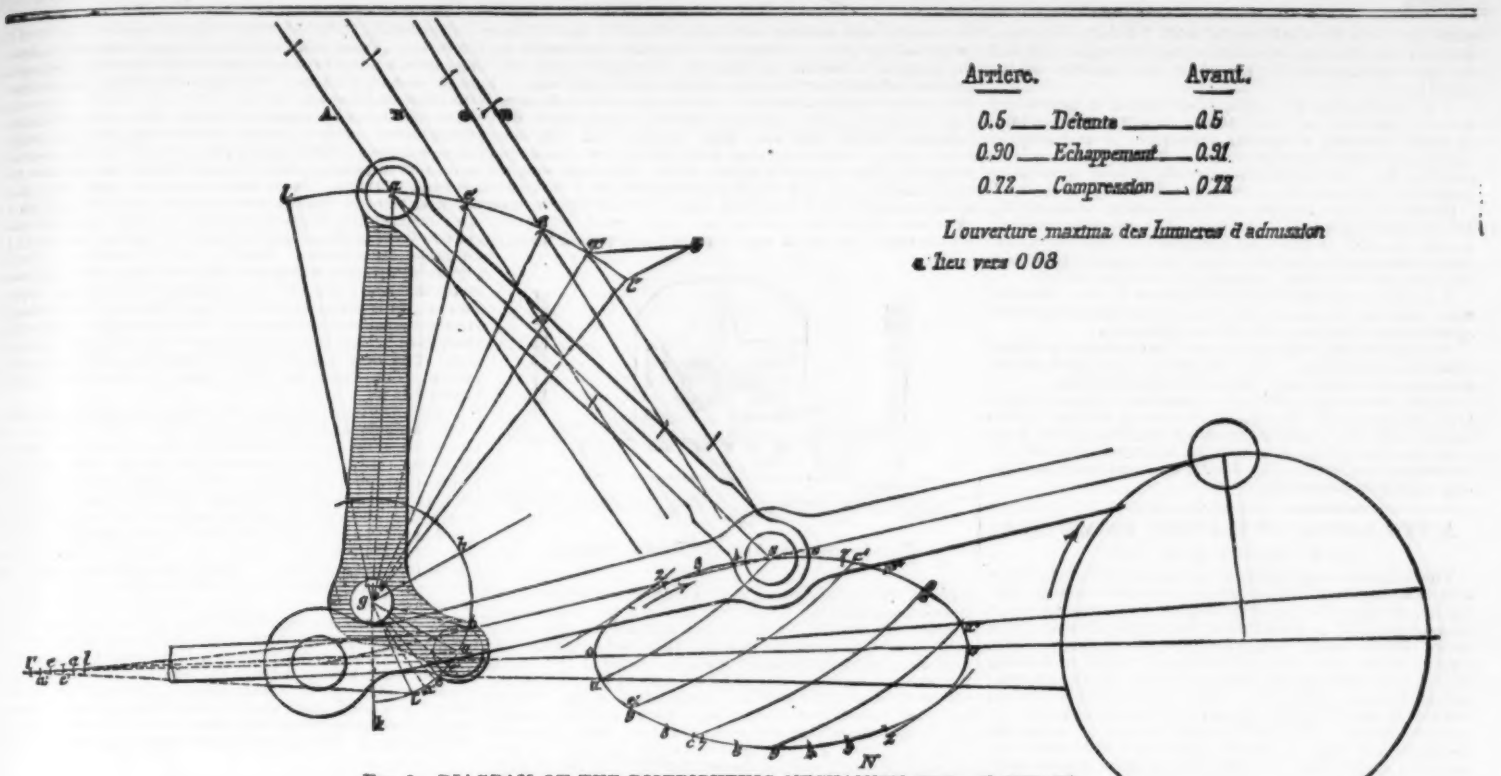

Arriere. Avant.
0.5 Détente 0.5
0.90 Echappement 0.91
0.72 Compression 0.72
L'ouverture maxima des lumieres d'admission a lieu vers 0.08

FIG. 2.—DIAGRAM OF THE DISTRIBUTING MECHANISM FOR AN INVARIABLE EXPANSION OF 0·50.

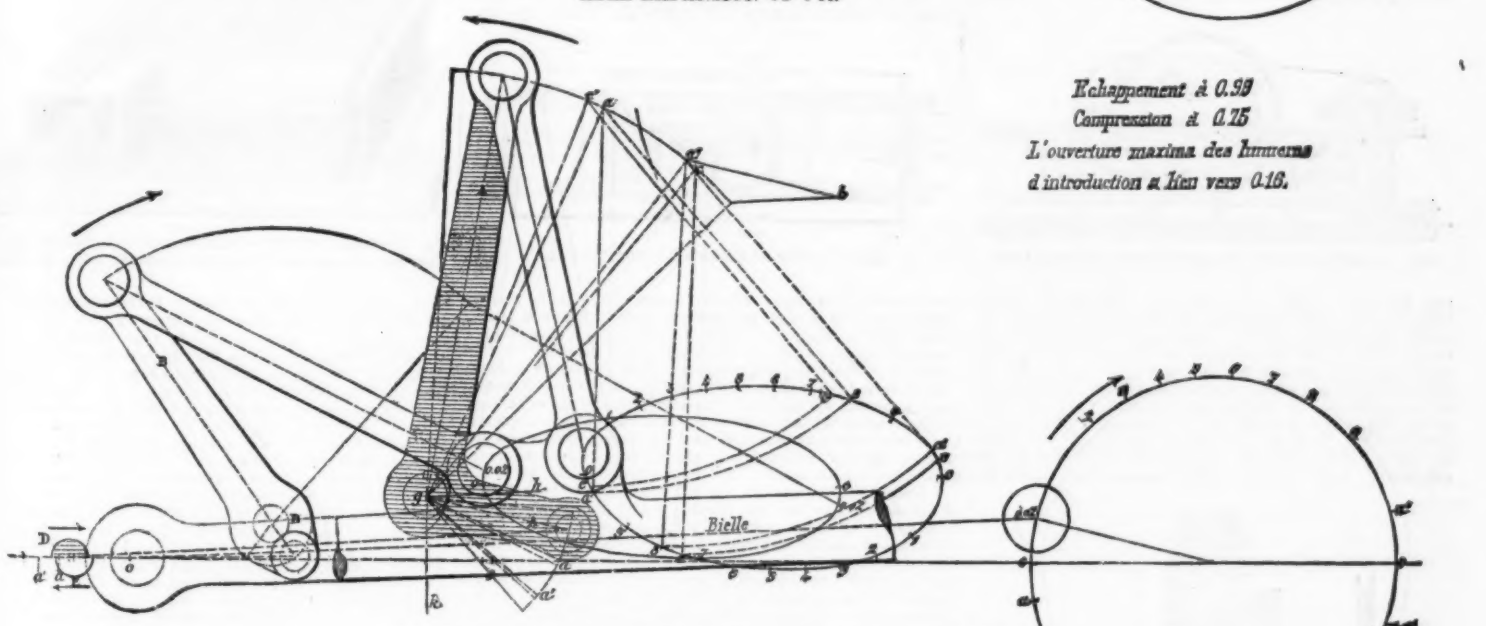


FIG. 3.—DIAGRAM OF THE DISTRIBUTING MECHANISM FOR A MEYER EXPANSION, WITH A MAXIMUM INDUCTION OF 0·80.

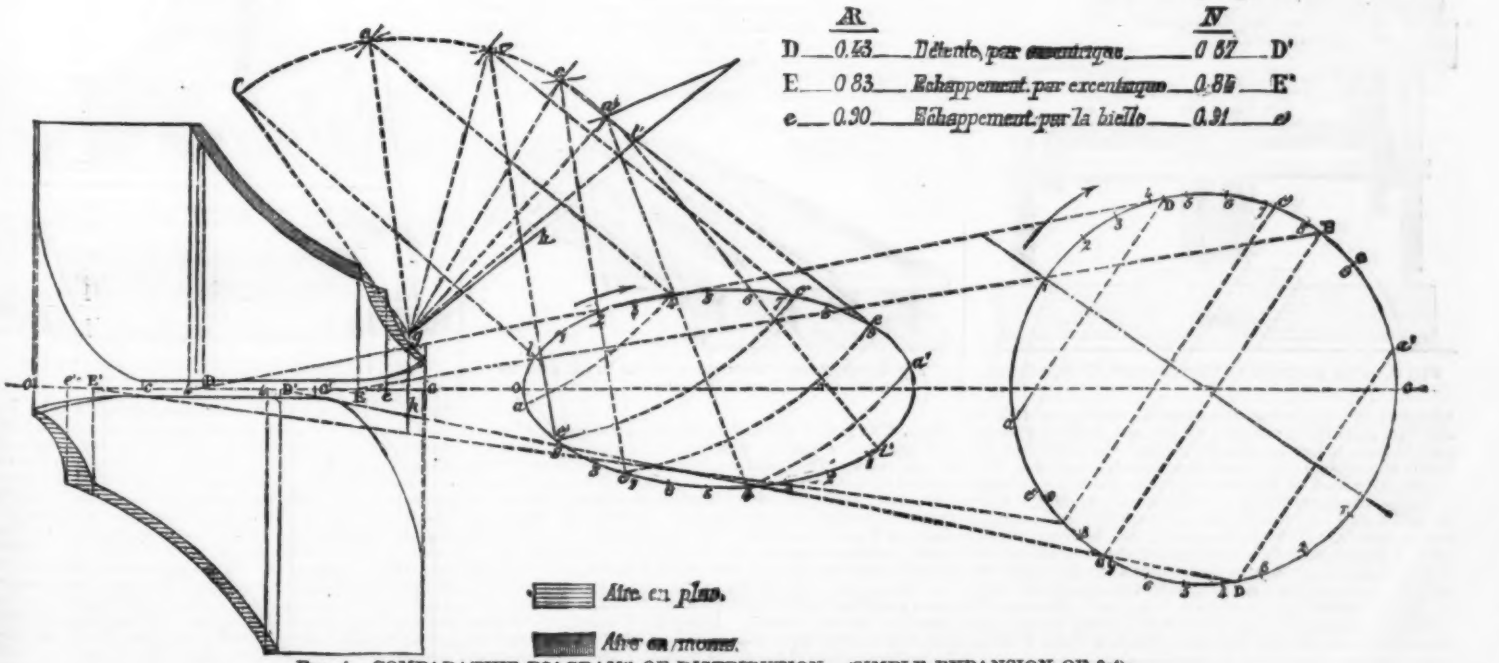

AR AV
D 0.43 Détente par excentrique 0.67 D'
E 0.83 Echappement par excentrique 0.86 E'
e 0.90 Echappement par la bielle 0.91 e'
Aire en plan.
Aire en relief.

FIG. 4.—COMPARATIVE DIAGRAMS OF DISTRIBUTION. (SIMPLE EXPANSION OF 0·4).

DE LAHARPE'S NEW MODE OF DISTRIBUTION WITHOUT ECCENTRICS.

guide-lever, we draw $g\,k$ parallel with $l'\,b$, and $g\,k$ perpendicular to the direction of the valve-rod, the angle $k\,g\,k$ will be that which should be given the two branches of the guide-lever.

If we remark that the degree of expansion is determined solely by the angle, a, of adjustment, it will be evident that, in order to obtain a variable expansion, it will only be necessary to cause the size of the said angle to vary. In practice, we obtain mechanisms which possess remarkable properties, but upon these we shall not dwell at present.

In order to show that the new arrangement devised by Mr. De Labarpe may be employed in all cases where an eccentric is used, we give, in Fig. 3, an application of the mechanism under consideration to a Meyer expansion presenting, through the principal slide-valve, a maximum admission of 0·8.

A and B are the respective guide-levers of the principal slide-valve and expansion plate, and D and E are the corresponding heads of the valve-rod and plate-rod.

The mechanism is figured in one of the extreme positions of the expansion-plate. The two extreme positions of this latter occur 0·2 after each dead-center of the crank.

During last winter a 30 H. P. compound engine, upright type, constructed by Mr. Boulet, was run in the shop of this builder with this kind of distribution applied to the large cylinder alone. Fig. 5 represents, approximately, the arrangement employed. The results obtained were satisfactory.—*Annales Industrielles.*

A NEW SYSTEM OF ELECTRIC TRAMWAYS.*

By M. HOLROYD SMITH, C.E.

THE proposal to lay tramways in Halifax excited my attention as an engineer; and as our town presents unusual difficulties, owing to the narrow, tortuous, and steep streets, it became necessary to consider the best means of coping with them. Horse traffic was, *prima facie*, out of the question, owing to the cost of horse flesh and cruelty to animals. Steam was questionable, first, on account of the growing public objection thereto, and, secondly, the danger incident to running heavy engines up and down steep gradients in crowded streets. The cable system, though an admirable one in its way, and calculated to overcome the natural obstacles of a hilly district, seems in my opinion inapplicable, owing to the enormous outlay it would involve (many of our roadways being of solid rock), the great cost of working,

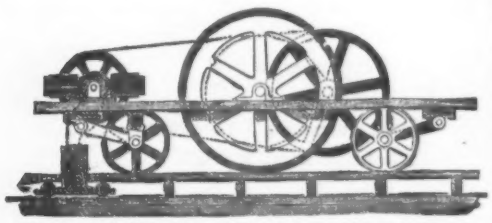


Fig. 1.—Side Elevation of Experimental Electric Truck.

and the small traffic to be expected. Pneumatic engines being open to objections similar to steam, my thoughts naturally turned to electricity. Such rapid strides have been made of late in the development of this wonderful agency that it has now arrived at that state when it may be considered among the numerous facts and forces at the disposal of the engineer. In endeavoring to make electricity practically applicable for the purpose named, I started with the following propositions: First, safety to the public; secondly, protection of the electric force; thirdly, tractive efficiency. It is, perhaps, hardly necessary to remark that

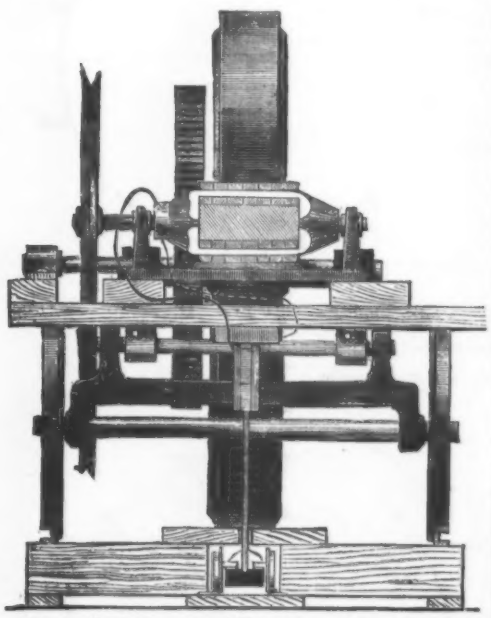


Fig. 2.—End Elevation of Experimental Electric Truck.

wherever the conductors are exposed, whether as rails or side bars, liability to accident exists; and, further, that not only is there a loss by leakage through the earth, but the line is also subject to be short circuited accidentally. The system advocated by Professors Ayrton and Perry, though probably admirable from an electrician's point of view, seems to me to be wanting in practicability and open to minor defects. Without discussing the systems already tried, it is perhaps sufficient to say that the propositions laid down seemed to me to have their solution in the simple expedient of employing a central channel to contain the wires or bands conveying the electric force, and effecting the haulage by means of a large wheel with a broad face running upon the surface of that channel. After carefully working out designs and making such calculations as lack of data permitted me to do, I proceeded to make experiments for the purpose of testing my theories. First, as to the comparative efficiency of the large wheel *versus* small ones. I laid a short length of rails in a warehouse with a flagstone floor, gauge 2 ft. 9 in., and constructed a rough truck with two small wheels and one large central one. The large wheel was 3 ft. diameter, 6 in. wide, and the two small ones were each 12 in. diameter, 1¼ in. wide. The truck weighed exactly half a ton, and was so proportioned that 5 cwt. came upon the large wheel and 5 cwt. upon the small wheels; both axles were fitted with gear so that either could be moved. To the end of the car a rope was tied, and passed under a

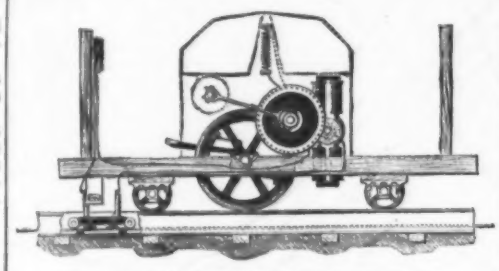


Fig. 3.—Section of Smith's Electric Tramcar.

pulley fixed to the ground, and thence over a pulley hung from a beam above. To the end of this rope weights were applied, and the small wheels made to revolve. The truck moving forward drew the rope and lifted the weights. The load was gradually increased until it reached 1 cwt., when the wheels began to slip; at 1 cwt. and 14 lb. they simply revolved round and round and would lift no more. Motion was then transferred to the large wheel, and the weights again applied until the lead reached 3 cwt. 3 qrs., when the tackle gave way, there being not the slightest slip. I considered this result sufficiently satisfactory to make it unnecessary to renew the tackle. My next experiment was also a rough one to test the possibility of collecting the electricity from the central channel and converting it into dynamic

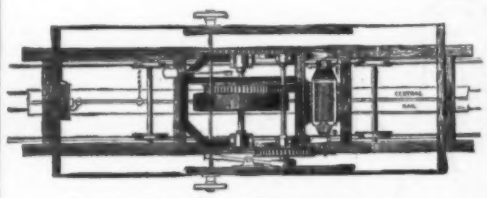


Fig. 4.—Plan of Smith's Electric Tramcar.

force to drive the large wheel. I therefore laid a line 50 yards long, 3 ft. gauge, and placed upon it a rough truck, illustrated in Diagrams 1 and 2. The truck was simply made of rough planks, as illustrated, and was laid in the grounds of Moorside, the residence of L. J. Crossley, Esq., who kindly placed at my disposal his electrical apparatus and permitted me the use of his admirably-fitted workshop. Copper bands similar to those used for lightning conductors were laid within the channel, and upon them ran a wooden trolley, part of which I now show you. Connection was made between the trolley and the truck by means of a box or frame shutting upon it, the box used being here for examination. The car and gearing were of a rudimentary character; the main wheel was 4 ft. diameter, 7 in. wide. The electric motor employed in the first instance was one of Siemens' medium dynamos, but from some defect it would hardly revolve alone, though the electricity from a Gramme machine was conducted to it with little loss. I then took a Siemens D 3 dynamo, and modified the gear, and, though this was far too small a motor for such a load, viz., one ton, the whole mass moved slowly up the gradient of 1 in 20. This experiment was sufficiently satisfactory to lead me to further efforts, I therefore laid a fresh line nearly 100 yards in length up the same walk, gauge 18 inches, and made a car as illustrated in Diagrams 3 and 4. The same Siemens D 3 machine was employed as before. The gear consists of a brass pinion upon the axis of the dynamo, gearing into a lantern wheel, with wooden pegs in lieu of teeth. This wheel is free to revolve upon its shaft, and is fitted with a frictional clutch actuated by the two hand wheels, one on either side of the car. Upon the same shaft is keyed a pinion gearing, with another lantern wheel attached to and forming part of the main driving wheel, which is 2 ft. diameter and 4 in.

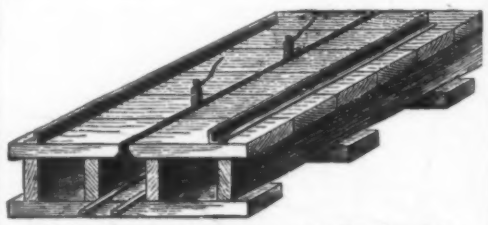


Fig. 5.—Showing Construction of the Track used for Electric Tramcar.

wide. The face of this driving wheel consists partly of wood and partly of a special material, to insure hold upon the central track. The brake is actuated by a treadle under the control of the driver's foot. The switch for connecting and disconnecting the electricity is attached to the dashboard in front. The track is constructed of planking, as shown in diagram No. 5; transverse sleepers are laid upon the asphalt walk, and upon them rest four longitudinal spars, the middle ones forming the sides of the central channel, and with the two outer spars support the top boarding, which consist of cross planking, so laid as to leave half-inch space over the center of the mid-channel. Every third board or covering plank is screwed down; the rest are nailed. This was done to facilitate removal in case of mishap. The tramrails consist merely of 1½ in. angle iron screwed to the surface of the planking. The conductors laid in this track consist of copper bands, $\frac{3}{16}$ by $\frac{1}{16}$; brass disks are soldered to them at intervals. These disks have small holes punched in them, and form a ready method of attaching the conducting bands to the bottom sleepers. The collecting trolley used is upon the table, and consists of two brass side frames insulated from each other by a block of wood. In each end of these fixings work guide or carrier wheels, and attached to the sides are cases containing slippers or skids free to rise and fall—this to insure contact in case of unevenness in the track or from vibration. Each brass frame has upon one end an upright plate or flat bar long enough and thin enough to pass through the slit in the top of the track. As the track in this instance consisted of wood, it was not necessary to insulate these plates. The electricity, therefore, collected by their respective wheels and slippers is ready for connection with the motor on the car by means of insulated copper wires. This trolley is made to travel with the car by simply passing a wooden bar between the two upright plates, the bar being held in fixings attached to the side frames of the car. The entire weight of the car with dynamo and gear is 16 cwt. The track, as before stated, is on a gradient averaging 1 in 22.

I do not propose to give you a tabulated list of amperes, volts, and ohms, curves of results, etc. These matters are rendered sufficiently interesting by those who make them a specialty. It is, I assume, practical results that are most wished for, and I therefore content myself with saying that though it is as much as three men can do to push the empty car up this steep hill, yet the electricity was so collected and used as to run it up at a moderate speed with six adults in the car. Total weight, say 24 cwt. It may be argued that the demonstration made is simply an experiment, and that there are many details inapplicable to daily work. Such a statement I am prepared at once to admit, viz., the demonstration so far is an experiment, but a most successful one. And I now propose to show how some of the details may be modified for actual daily use on a large scale. In respect to the car itself, perhaps enough has been said to show the principle involved and its practicability. As to the best electric motor to be used, that I admit is a debatable subject. Though not professing to be an electrician, I must confess that no electric motor that has yet come under my notice fulfills

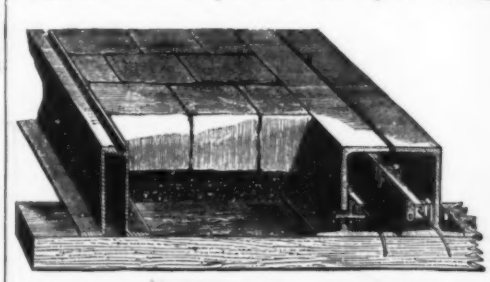


Fig. 6.—Section of proposed Tram Line on Smith's Patent, showing one rail and the central channel, with conductors.

what I conceive to be possible, or is constructed in a way calculated to make the best use of known forces. Again, as to gear, though I took care to test by experiment the strength of the wooden pegs used in lantern wheels, and found them practically applicable, and leaving sufficient margin of strength, and though their employment overcomes the objectionable noise, and forms a wheel easily repaired by an ordinary mechanic, yet, owing to the high speed at which electric motors must necessarily run, I hold it advisable to employ some form of compound differential frictional gear, and have therefore made experiments to that end, but they are not yet sufficiently advanced to bring before the notice of this society. Again, as to the surface of the traction wheel, I confine myself to the statement that it is of special material. Experience alone must determine how far it is suitable for the wear and tear of every day work; therefore I refrain at present from giving a precise description. Respecting the track, though I have designed and patented many modifications thereof, it is perhaps sufficient to give a description of one, and this I have endeavored to illustrate by Diagram No. 6, which is a section of a tramway. The rails rest on transverse sleepers, and the central channel consists of rolled or cast-iron girders of the form shown. At intervals along

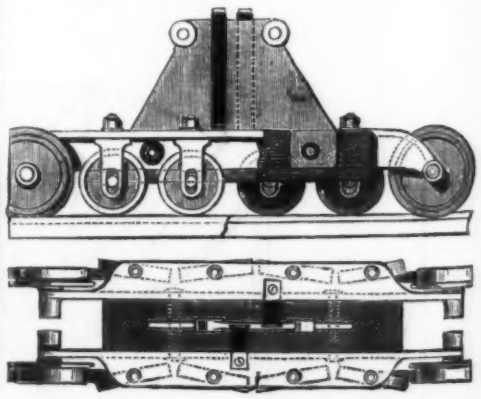


Fig. 7.—Elevation and plan of Collecting Trolley

the channel are bolted brass chairs on vulcanite blocks. These chairs are made to hold galvanized angle iron in the manner shown, and the same key that holds the angle iron also gripes a copper wire. By this combination a firm track is formed for the trolley, and the electrical resistance is minimized. I would also point out that copper wires might be used only for the leading conductor, return circuit being made by means of the metal of the channel itself. Ribs or flanges could be rolled or cast upon them for the wheels of the trolley to run upon. Wells connected with the street drains are placed at intervals to collect and carry away any water that may accumulate, and also to permit of the channel being occasionally flushed. Respecting the trolley, upon the table will be found a drawing (Fig. 7) illustrating one suitable for a full sized line. The channel in which it would have to run being of iron, the upright plates are distinct from the side frames, and they have channels formed

*Paper read before the British Association, Southport meeting, September, 1883.

in them in which insulated copper bands attached respectively to each side frame are placed. The electricity can thus be gathered from the conductors and passed to the car without short circuiting through the channel. To insure good contact with the conducting bands or rails, in addition to the guide wheels and in lieu of the slippers or skids a number of wheels are placed down each side of the trolley. These wheels are free to rise and fall in their bearings, which are so attached to the frames that the axis of the wheels may be placed at any angle with the line of motion, thus causing frictional as well as rolling contact between the periphery of these wheels and the rails, the relation between the frictional and rolling contact being adjustable. I will not weary you with any further details, but take this opportunity of stating that, with the assistance of those associated with me, I am prepared to construct a full sized tram line in any public street, or to convert existing lines into electric lines in accordance with my system, and to guarantee success, and I sincerely hope before the next annual meeting of this honorable association to be able to report progress.

ELECTRO-MAGNETIC RAILWAY BRAKE.

By A. WILKE.

THE idea of increasing the friction of the wheels of a locomotive when ascending a steep gradient by means of electro-magnetism is not novel. But as I have not yet seen this idea put into a practical shape, I may hope that the following construction will not be without interest for the reader:

Fig. 1 represents the course of the current and the magnetic distribution. The current passes horizontally round the wheel O, N, O, converting it into a magnet which stands with its north pole upon the rail, R, S, R. The current is led further in such a manner that it passes on both sides of the wheel, close over the rails. Thus these are also magnetized in such a manner that at the point, S, where the wheel and the rail touch, there is formed a south pole. The result is a very considerable increase of the adhesion between the wheel and the rail.

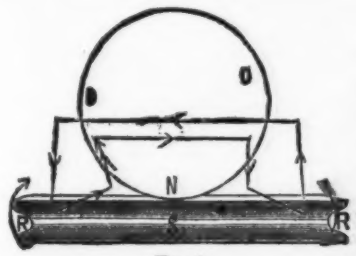


FIG. 1.

Fig. 2 shows the friction arrangement for three wheels.

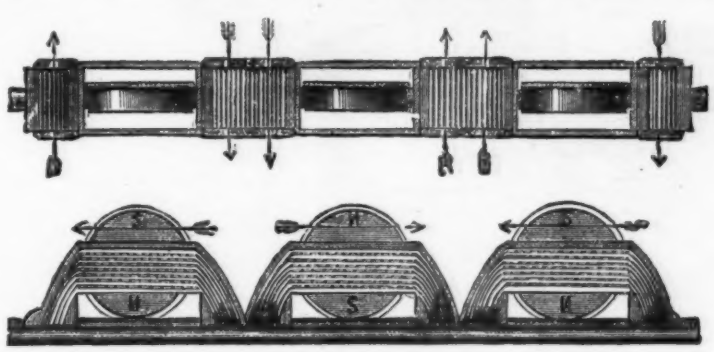


FIG. .

A copper or bronze frame supports the coils of wire, which are spread out at the parts where the wheels pass over the rails and partly infold them.

The magnetization is effected by a dynamo machine which derives its power either from the axle of a wheel or, as is preferable, is driven by a small special engine.

The application of this electro-magnetic friction is, of course, easiest in electric railways, and as these are to be recommended in mountainous districts on other grounds, the electro-magnetic friction will increase their advantages. —*Intern. Zeitschrift Elect. Ausstellung Wien.*

MAGNETIC INFLUENCE UPON ELECTRO-DEPOSITION.

THE accompanying engraving copied from a photograph represents the result of one of a series of experiments by Mr. Frederick H. Varley, to ascertain if it were possible to make magnetism build up a structure from electro-deposited metal, which structure should represent the magnetic lines more accurately than the coarse grains of iron filings. The shadow between the poles merely represents the back of the magnet out of focus. The vertical shadow below one corner of one of the poles bears no relation to the experiment.

Each pole of the horseshoe magnet was 1 in. square. The magnet was suspended, poles downward, in a solution consisting of equal parts by weight of sulphate of magnesia and pure protosulphate of iron dissolved in distilled water, and then diluted down to the specific gravity of 1·26. An iron plate placed at the bottom of the liquid was 1 in. wide by 2 in. long, and 2 in. of liquid were between it and the poles above. A current from two Daniell's cells was used, and the negative or zinc pole connected with the magnet, the positive with the iron electrode. The accumulation represented in the engraving was produced in three days of twenty-four hours.

It will be seen that the result was completely at variance from that which might have been expected from the well-known effects of iron filing experiments. The north and south poles appear to be isolated, and the chief deposition is not between them, the latter being the case when iron filings are used. Moreover, instead of a uniform deposit of metal having a smooth surface, a coral-like aggregation of iron atoms took place, and that almost entirely on the margins of the poles. The philosophical conclusions drawn by Mr. Varley from this are, that the current flowing from the dissolving to the receiving pole is deflected by the action of magnetism; this action practically cuts off the current where the magnetic field is the strongest, and the deposit is thus deflected nearly equally to the margins of the poles. Indeed, the greatest deposit is on the outside margins, where the magnetic action is the weakest.

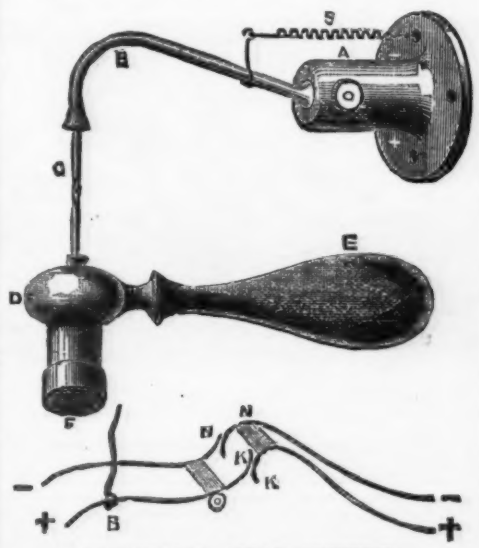
Another experiment consisted in depositing iron on a mercurial surface, when a uniform film of laminated iron was obtained, having a mirror-like surface. A helix was

then placed around the receiving and depositing poles, and the experiment repeated. Instead of the uniform film, fine vertical needles of iron parallel with the magnetic axis grew up from the flat iron plate previously deposited, illustrating in another form Groves' experiment with finely-divided iron suspended in a liquid, in which the liquid became less opaque to light during the passage of the current through the helix, in consequence of the particles of iron arranging themselves in the lines of magnetic force.

The reason why, in the experiment represented in our engraving, the iron assumes coral-like excrescences instead of more regular forms, is, according to Mr. Varley, the virtual reduction of the area of the surface of the receiving poles by what may be termed magnetic insulation.—*The Engineer.*

ELECTRICAL CIGAR LIGHTER.

THE only new apparatus in the Edison exhibit at the Vienna Exhibition is a cigar lighter. Inveterate smokers have been heard to declaim against the introduction of the electric light because the incandescent lamp does not offer certain facilities to them in the indulgence of their favorite habit. A variety of ingenious devices have been contrived to provide the required light, and Edison has this device among the number. The cut shows his cigar lighter. A



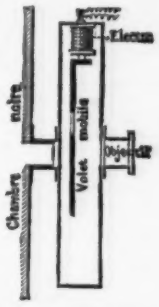
ELECTRICAL CIGAR LIGHTER.

cylinder, A, which can be screwed against the wall, carries the contact making parts. B is a curved brass arm carrying the wires. This arm is movable. Normally it is kept in the position shown, because the handle, E, is weighted, and under this condition there is no contact. When, however, the lighter is to be used, it is lifted up by means of the handle, E, the spring, S, then comes into play, pulls back B, and makes contact. D is the holder for the plug, F. The latter consists of a thin asbestos disk sewn across with platinum wire. One end of the platinum is connected to a side contact, the other with a bottom contact on the plug. These contacts when the plug is screwed into the holder, bring the platinum into contact with the conductors. The method of making contact in the cylinder, A, is shown at N N' K K'. When the spring, S, raises the arm, B, N is brought into contact with N', and K with K', thus completing the circuit.

AN ELECTRIC OBJECTIVE FOR INSTANTANEOUS PHOTOGRAPHY.

THE advantages presented by the use of gelatino bromide plates in photography are causing them to come more and more into use. The very great sensitiveness of these plates requires the use of special apparatus for reducing the time of exposure to fraction of a second only. One of the most recent and satisfactory devices of this kind is Mr. Brunot's electric cut-off, shown in section in the annexed figure taken from *La Nature*.

The apparatus consists of a rectangular box carrying upon its front surface the objective, properly so called, and, upon its back, a copper collar which closely embraces a copper tube fixed to the front of the camera.



VERTICAL SECTION THROUGH THE AXIS OF THE OBJECTIVE.

In the interior of this box, which may be inclined more or less from the vertical, so as to increase or decrease the time of exposure, there is a movable shutter which carries a soft iron armature at its upper part, and which contains at its center a rectangular aperture that may be reduced, according to the intensity of the light, by means of two sliding pieces fixed with screws. This movable shutter is held by the magnetization of a Hughes electro-magnet connected by means of flexible wires with a pocket pile of the size of a small bon-bon box.

This pile, which contains asbestos saturated with bichromate of potash, emits a current when a central button is pressed in order to put the zinc in contact with the bichromate.

When this current is broken, the electro-magnet allows the shutter to fall by its own weight, or through the action of a spring. The time during which the objective is uncovered, ranging from one-fifteenth to one-twentieth of a second, is sufficient to make an impression upon the sensitive plate.

To demonstrate the quickness with which the operation may be performed, it suffices to say that it has been found possible to obtain with the apparatus a very sharp photograph of a train running at about fifteen miles an hour from Amiens to Tergnier. The smoke from the locomotive, although blown back by a very strong wind, was reproduced with exceeding sharpness.

This cut-off presents the following advantages: It is completely hermetical, and it is devoid of any catch arrangement in the movable shutter, thus preventing shocks in the camera and giving greater sharpness to the images.

To raise the shutter after an operation, and put the armature in contact with the electro, it is only necessary to give the apparatus a half turn on the copper tube of the camera. A screw placed at the side permits of the shutter being kept open for focusing. With sufficiently lengthy conductors, the operator may take a photograph of himself at a great distance from the camera, either alone or standing among a group of friends.

BORACIC ACID AS A FOOD PRESERVATIVE.

IN *Science* Prof. L. P. Kinnicutt, of the Worcester Free Institute, reports an analysis of a somewhat widely advertised "food preservative." He finds the essential ingredient to be boracic acid (and borax), but makes no statement with reference to the effect of these substances on the human system. In spite of the fact that Prof. S. W. Johnson considers this particular preservative "no more harmful than common salt," and in spite of the fact that other authorities have recommended boracic acid for the preservation of food, it is by no means certain that its use is to be advised. Dr. Forster, of the Laboratory for Hygiene, in Amsterdam, has recently published the results of some experiments made by one of his students on himself. Known quantities of food, with and without the addition of boracic acid, were taken and the fæces submitted to analysis. It was found that the effect of the boracic acid (from one to three grammes being taken daily) was to increase the total amount of dry excrement, also the amount of excreted nitrogen. After discussing the results of these experiments, Dr. Forster says:

"From what precedes, it appears that the addition of boracic acid to the food leads on the one hand to an increased secretion of bile, and, on the other hand—what is of more importance—to an increased discharge from the intestines of albuminoid substances which come mostly from the food taken. This last effect on the human intestine cannot be considered as a favorable one, to say the least.

"If further analyses give the same result—as there is reason to suppose they will—it will follow that boracic acid is not as well fitted for preserving articles of food as is generally believed.

"It will, moreover, be necessary to be especially cautious about the addition of the acid to milk which is to be used by young children."—*Berichte der deutschen Chem. Ges.*, No. 12, 1883.

COMMEMORATIVE MONUMENT, ST. STEPHEN'S CATHEDRAL, VIENNA.

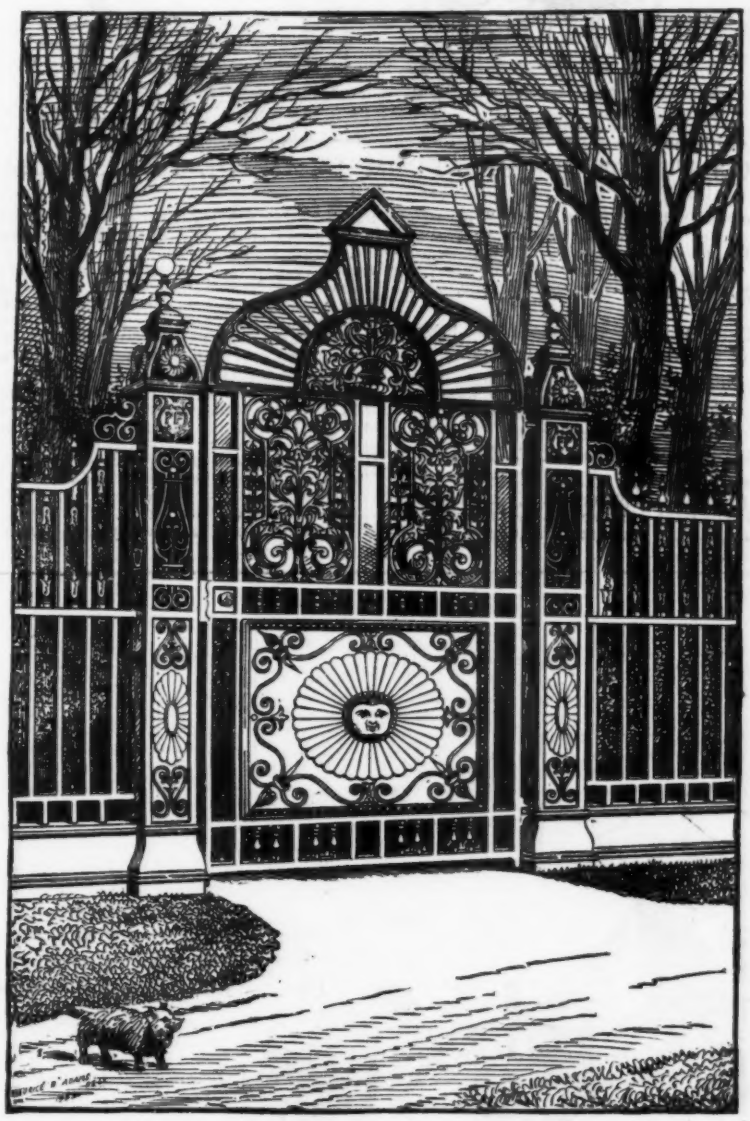
MONUMENT IN ST. STEPHEN'S CATHEDRAL, VIENNA.

Our engraving represents the monument to be erected in St. Stephen's Cathedral, at Vienna, in commemoration of the delivery of Vienna from the Turks in 1683. The monument was designed by Mr. Edward Hellmer, who received the first prize in the competition.

The middle group of the monument represents Count Ruediger von Starhemberg, the liberator of Vienna, mounted on a horse and resting his field-marshal's staff on his left thigh. The horse is represented as treading on a fallen Turk, who, in dying, raises the green flag of the Prophet. Count Von Starhemberg is accompanied by the color-bearer of the Vienna citizens and the leader of the Vienna students. The statue on the left hand end of the base represents Bishop Kollonitz, and that on the right-hand end Burgomaster Von Liebenberg. An angel soars over Count Von Starhemberg, and holds a laurel wreath in its right hand, and a cross, the symbol of faith, in its left hand. Two Corinthian columns are arranged at each side of the central group, and each pair of columns supports a group of statuary; the one at the left hand representing the Polish King Johann Sobieski, and the Elector Max Emanuel, of Bavaria; and that at the right representing Karl von Lothringen and Johann Georg III., of Saxony. A statue of the Emperor Leopold I., in full armor, crowns the entire monument. The victory of the united armies over the Turkish host of Kara Mustapha is represented in relief on the base.—*Illustrirte Zeitung.*

IRON ENTRANCE GATE.

An endeavor has been made in this design, recently executed by the Coalbrookdale Company, to render the general



ORNAMENTAL IRON GATEWAY.

forms, as well as the ornamentation, suitable for cast metal, with some regard to the value of repeats, so desirable in work produced by the foundry. The lower panel shows the same on both sides, like the remainder of the work, and is made up, consequently, in two thicknesses. It has the conventional figure of the sun, adapted from the design of some old plaster work at Rome. The standards and railings are also in cast iron, as well as the plinth, which is built on a brick or stone foundation. The designs were prepared by Mr. Maurice B. Adams, A.R.I.B.A.—*The Building News.*

COLOR HARMONY.*

By G. H. Morton, Jr.

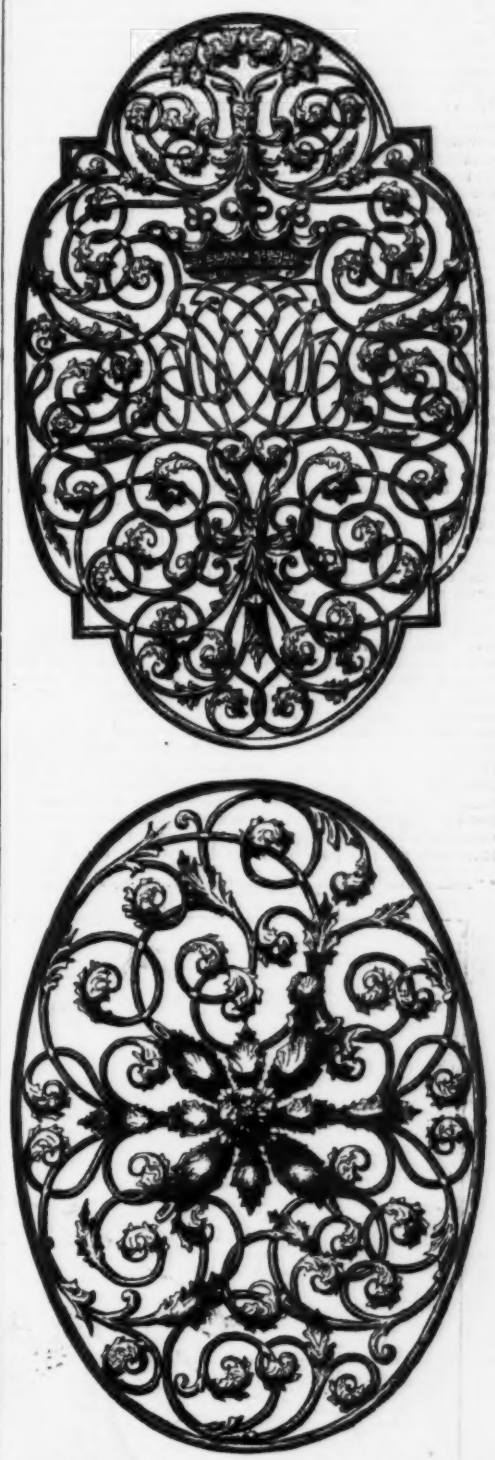
Harmony of color consists in three color sensations being equally excited, either jointly or separately, by all the colors of a composition, the mean or general tone of which will consequently be some shade of white. It therefore appears only necessary to ascertain the relative proportions of the three fundamental colors in order to obtain a correct basis of harmony. The subject of color, however, has two sides—the scientific and the artistic. Physicists have proved that the three primary sensations are scarlet, green, and violet, while most artists still support the old theory that the three primary pigments are crimson, yellow, and blue. It has therefore to be determined in the first place, which of the two sets is correct, or are both? Admitting that scarlet, green, and violet are the three primary sensations because supported by Helmholtz, Tyndall, and, I think, by all modern physicists, we have to inquire upon what foundation the crimson, yellow, and blue theory rests, and what relation these colors bear to scarlet, green, and violet. We cannot obtain any of the colors of the primary pigments by mixture, but conversely almost all other colors are obtained from them. The particular hues of red, yellow, and blue which mix best with the greatest number of other pigments are a crimson red, a yellow neither green nor orange, and a blue of a greener hue than is often implied by that term. Crimson, yellow, and blue have therefore been named primary colors.

Each of these colors appears to have the power of exciting two primary sensations, and is therefore complementary to green. Yellow excites scarlet and green, and is complementary to violet. Blue excites green and violet, and is complementary to scarlet. Colors approximating to the primary sensations may be obtained by combining two primary pigments. This relationship of the two sets proves that the primary color sensations are equally excited in both sets.

It will be seen that harmony of color being produced by scarlet, green, and violet, will also be produced by crimson, yellow, and blue, and that whether we adopt the scientific or the artistic theory as a basis for color schemes, our results as to harmony will be the same—provided the pigments we employ are combined in a scientific manner, as color. True combinations of colors as components of white light, can seldom be obtained in the ordinary way by mixing pigments together. One of the most convenient methods for colorists is by a rotating disk, on which the colors are placed. The disk is then revolved rapidly till the colors appear blended. By this means the following results are obtained: Scarlet and green produce yellow; scarlet and violet, light-crimson or pink; green and violet, blue; yellow and blue, gray. These results differ considerably from the colors generally obtained by mixture, and I think sufficiently prove the errors caused by combining colors as pigments, and not as components of white light.

Proportion in color harmony is of much importance. Until recently the theory was that, dividing white light into sixteen parts, the proportions of yellow three, red five, blue eight, would be obtained; and no composition was considered harmonious unless these colors were present, either pure or combined, in these particular quantities. Professor Rood, however, in a work entitled "Modern Chromatics," gives an almost opposite hypothesis, and his calculations are especially valuable from the fact that, in addition to his being a professor of physics, he is also a practical artist, and therefore conversant with both sides of this subject. To go over his calculations would be tedious and occupy much time; but having abstracted crimson, yellow, and blue from some twelve colors he enumerates, I find that their proportions to white light are respectively about four, seven, five; quantities, especially as regards yellow and blue, almost the reverse of what they were formerly considered to be.

Color harmony is sometimes divided into two parts. Chevreul divides it into harmony of contrast and harmony of analogy. Strictly speaking, there can be no such thing, in color, as harmony of analogy; because all true harmonies, when reduced to their simplest form, contain the greatest possible contrasts. Chevreul subdivides analogy into three parts, and names them harmonies of scale, of hue, and of a dominant colored light. The first is produced by different tones or shades of the same color only being employed. Such a scheme, it is scarcely necessary to point out, would not be harmonious. The more saturated or intense the color



SUGGESTIONS IN DECORATIVE ART.—WROUGHT IRON GRILLES IN ST. GILES' CHURCH, LUBECK, SEVENTEENTH CENTURY.

the worse would be the effect, for any color when lightened necessarily brings in a portion of the remaining colors, by which it is neutralized, with the white introduced—hence all light tones of colors are more or less satisfactory. Shades of a color are also not unpleasing from the fact that much of the color is absorbed by the black. An instance of this so-called harmony was demonstrated a year or two ago in the adoption of very dull colors in decoration and dress. In such schemes proper harmony seldom existed, but discord was hidden by the introduction of so much black or gray. Chevreul's harmony of analogy of hue is produced by any colors of analogous tones or shades, and may therefore include colors which constitute true harmony. An analogous effect by a dominant color, Chevreul's third harmony, results from one color being added to all the others in the composition. It can, perhaps, best be realized by viewing a scheme through colored glass; the color of the glass seems to pervade everything. A deep red sunset scene is also an example, red being the dominant color.

The prismatic image illustrates an analogous arrangement of harmonious colors. Beginning at the red end we have crimson, scarlet, orange, yellow, green, blue, and violet, with the most delicate hues between, so that where one begins or ends we cannot tell. All the contiguous colors, so

* From a paper read before the Literary and Philosophical Society of Liverpool.

to speak, are analogous, and yet the whole includes the greatest possible contrasts. It may, I think, be concluded that analogy is the method by which contrasting colors should be connected, and not placed in violent opposition, and in this sense may be included in the term harmony, but is incomplete in itself. Analogous color schemes have lately been termed "tone harmonies" by modern colorists, owing to the late prevalence of dull tints—tints, in many cases, in which little color is visible at all. The harmony, as the term implies, is of tone and not *of* color. Mr. C. W. Dempsey, in an article published about three years ago, stated that Mr. Morris, in decoration, and Mr. Whistler, in painting, were among the chief exponents of "tone harmonies," and the success achieved by them was well known. But Mr. Morris appears, to me, to be now more inclined to contrast or, at least, to more distinct and definite color. Mr. Whistler seems as peculiar as ever, his recent "arrangement" being proof enough.* In the article referred to, the two sides of color—the science of color, and the art of coloring, and the technical meanings of the principal terms in both—are pointed out; these terms are harmony and melody. Harmony I have already defined, and Mr. Dempsey defines melody as "two or more colors in such juxtaposition that they form a part or the whole of the prismatic spectrum, whether in their natural, direct order, or inverted." Melody, then, seems to be another term for the so-called harmony of analogy, and a better one, because it does not confound two meanings in one word, and is applied to the art of coloring, whereas harmony is applied to the science of color. Both terms are compatible, for when harmony is obtained by melodious means our compositions are then perfect. It has been argued that there are two schools of colorists. First, that of harmonious contrast; second, that of melodious intervals; but melody appears to be the proper manner of arranging harmonious colors, in the same way that harmonious notes are uninteresting till a melody is composed. Melody in one color is to some extent similar to playing on one note.

This being the case, how is it that so many apparently inharmonious compositions have been successful? There are many reasons, mostly unrecognized or unthought of. Many rooms have been decorated entirely in dull greens or blue greens, but contiguous rooms may be in hues of yellows and brown, consequently the two apartments together would be harmonious, separately melodious; indeed, our color appreciation would be momentarily increased on passing from one room to the other. Then furniture and art objects generally bring in some contrasting colors. The chief cause, however, is due to the low key in which the large surfaces were colored, the actual amount of pure color being very small, the greater portion being gray, in which the three primaries are present in harmonious proportion. It is seldom, perhaps never, that the three primary colors are absent in decoration, taken as a whole, and including carpets, furniture, everything. All in the room, and all that can be viewed out of the room, must be taken account of, as also the amount of light received into it, and the color of that light. A room decorated in melodious tones of reds, in which no opposite colors were permitted, having a large window looking out upon a green lawn, might be strictly harmonious in daylight, though at night, when the green was shut out, the impression would doubtless be hot and oppressive. It would appear that the older colorists adopted harmony, the presence of the three primary colors, either pure or in combination, in certain relative proportions, as a rule not to be violated; but they often neglected the subtle melody by which means melodious harmony is most successfully arrived at. Hence their schemes are inclined to be crude and unrefined. The foundation upon which they worked, as to color, but probably not as to proportion, was correct. They worked under the delusion that the contrast of pure primary and secondary colors because harmonious, were beautiful; that bright red and bright green, or bright blue and bright orange, when contrasted, produced perfect composition. It is needless to say that such would be extremely vulgar, unless melodiously arranged either by tones or shades, or by those intermediate hues which would melodiously connect them, or by both. On the other hand, the tendency of modern colorists of the so-called melodious school is to neglect harmony, which should be the foundation of their ideas; mistaking the method for the fact, and producing effects at first pleasing, but eventually becoming tiresome and wearying. It may therefore be concluded that harmony and melody are essential in the art of coloring. The scientific fact that white light causes three principal color sensations, all of which must be equally excited, otherwise the eye gets wearied and probably injured, must not be neglected. These three sensations are, as it were, the harmonious notes of color; the art of composing them may be termed color melody.

* "Arrangement in Yellow and White," Fine Art Society's Rooms, 1883.

DESIGN FOR A SLEIGH.—FROM LE GUIDE DE CARROSIER.

THE NEW U. S. COURT HOUSE AND POST-OFFICE, PEORIA, ILL.

THE drawing we give of this very handsome public building, designed by Mr. Hill, is from a recent number of the *American Architect*.

THE PREPARATION OF COTTON.

THE mixing and preparing of cotton for the cards, although comparatively a simple operation, is in reality one of the most important processes in the manufacture of cotton yarns and cloths. Many manufacturers and carders pay so little attention to this part of the work that one not acquainted with the nature of the operation and results that follow, might suppose it to be a matter of no importance how it is executed. In many cases the work in the picker-room is delegated to one whom the less he knows the better he fills the bill. Not unfrequently is it the case that a hand who can not execute the work in another department is sent to the picker-room. This is all wrong, and against the practice we wish now to speak. The same manufacturers who follow this policy wonder why it is that their yarn is not as smooth and strong and even as that made by their competitors, who use no better stock, or have no better machinery. If they would open their eyes and go into the picker-room more frequently, they would soon see the cause of their failure.

In selecting a picker-room care should be taken to have plenty of space for the machinery, and large floor space for cotton bins as well as room for the finished laps. We would lay extra stress on having plenty of space for bins. When a lot of cotton is received consisting of a number of bales, a note should be made of the character of the staple, whether it is all of one kind or of several different varieties and qualities. Each variety should be placed by itself, and a memorandum taken of the number of bales in each lot.

Having received all of the lot, be it ten, twenty, or fifty bales, we prepare to open and mix it. We take one or two bales of that kind of which we have received the most, and open the bale, removing hoops and bale cloth. Spread the staple out thinly over the floor of the bin, shaking and loosening it as much as possible. Then take a proportionate share of one of the other varieties and proceed in the same manner as with the first, spreading it out in a layer on top of the first lot, and so on until there has been spread and opened out a proportionate share of all the varieties. Repeat this until all the bales have been thus spread out in successive layers. This is done so that the different qualities and varieties may get thoroughly mixed, and all parts of the bin may contain equal proportions of every kind.

This seems simple and is easily done, yet is neglected by

THE NEW U. S. COURT HOUSE AND POST OFFICE, PEORIA, ILL.

many, though they know it to be of the utmost importance. The cotton does not all come from the same plantation, nor even from the same section of country, hence it is not all alike. Some bales contain better staple than others. Some contain more moisture than others. Some are of a yellow color; others of a blue-white cast. Some are compressed, some are loose-packed, etc. The object in carefully mixing is to get a thorough mixture of all the varieties, so that when they are made into laps by the spreader and brought into the card-room, one can depend on all the laps being uniform. Nobody wants to find one with long staple cotton and another with short staple; one moist, another dry, etc. To have good, even yarn, uniformity is required here, and this is the only way to get it.

Care should also be taken to see that the boy who feeds the willow or opener does not take a number of armfuls of cotton from one spot in the bin; he should be compelled to use a rake and to rake down the edge of the pile from the top to the bottom, thus insuring a thorough mixing. It has also been found to be an advantage if the cotton is brought into the mixing or picker-room, and thus mixed a week or two before required for use. If these small details are attended to, and the machines be kept clean and clear from dirt, not allowing the dirt receptacles to become filled up, the carder will find the sliver from cards or railway head uniform, and it will not be necessary for him to be constantly altering the draught on the drawing frame with every fresh set of laps. There will be very little variation from beginning to end of mixing.

Many mills do not follow the above plan; but take one bale at a time and open it in front of the willow, and push it through the willow and other preparatory machines. When that is all through, then another bale is opened and they proceed as with the first, paying no attention to the mixing of the different bales. The result of such a mode of procedure is uneven yarn, not of a uniform quality, and it will bring a lower price in the market. The carder is kept busy watching his drawing frame and altering it back and forth, so that he will have something like uniform yarn. His time is taken up here which ought to be spent looking after other parts of the work, and there is more waste than necessary in the card-room. The yarn does not spin well, one day spinning first-class, while upon the next it goes so badly that the girls minding the frames cannot keep the ends pieced up; hence, there is more waste at this point. There is nothing but trouble, vexation, and loss from beginning to end, and yet manufacturers who allow such things say: "We do not understand why it is that we can't make as good yarn as others. Why we should have so much waste. We buy just as good cotton, and have equally good machinery, yet do not get as good a result." No one need wonder if such is the case with any manufacturer who pursues such a foolish course at the very outset of the process of manufacture. As much attention should be given to details in the picker-room as is given in the after processes, which are deemed by many to be of greater importance.—*T. T. T., Textile Record.*

NEW PROCESS FOR ALUMINUM AND ALUMINUM ALLOYS.

THE inventor is Mr. H. Niewerth, of Hanover. In his first process ferro-silicium is mixed with fluoride of aluminum in proper proportions and the mixture is submitted to a suitable red or melting heat, when the charge is decomposed into volatile silicon fluoride, iron, and aluminum, the two latter bodies forming an alloy. In order to obtain the valuable alloy of aluminum with copper from this iron-aluminum alloy, the latter is melted with metallic copper the copper will then, by reason of greater affinity, unite with the aluminum, while the iron will retain but an insignificant amount of aluminum. On the mass cooling the copper-bronze and iron separate out in such a manner that both bodies can be readily isolated. In place of the pure aluminum-fluoride, cryolite, which occurs in nature, may be advantageously employed, or aluminum chloride may also be used. In the latter case silicon chloride and iron aluminum alloy are formed. Or again pure silicon and aluminum fluoride, or cryolite, or aluminum chloride may be used, when pure aluminum is obtained. In the second process the compound of aluminum with chlorine or fluorine decomposed by any means into a volatile state is brought, strongly heated, into contact with a mixture of 62 parts of carbonate of soda, 28 parts of coal, and 10 parts of chalk, which is also in a highly heated condition. From this mixture sodium is disengaged, and this reduces the gaseous fluoride or chloride of aluminum in such a manner that the nascent sodium generates free aluminum from the fluoride or chloride as the case may be. In place of the above mixture other suitable mixtures which produce sodium may be employed, or mixtures may be also advantageously used from which potassium is formed. In another process the newly invented furnace may be advantageously employed, but the process may also be carried on in a crucible or other furnace. The furnace in question consists of three shaft furnaces made of fire-resisting material, two of which are made to shut by means of some contrivance, *e. g.*, a convex cast iron cover. These furnaces communicate with the other furnace by channels, which can be closed by slides. Blast pipes are fitted to two of the furnaces, and all three are fitted with discharge apertures. Short tubes connected with a steam reservoir admit steam to the two furnaces, which are filled with some suitable fuel, *e. g.*, coke, and by the admission of the blast are blown very hot. The covers are meanwhile lifted up. The middle furnace is then charged with three charges in proper order. The first charge consists of a mixture of carbonate of soda (NaO,CO_2) + carbon (C) + sulphur (S) + alumina (Al_2O_3). The second charge is sulphate of alumina, the third charge a flux, preferably a mixture of the chlorides of soda and potash. This furnace must be strongly heated at the beginning of the operation; it is best to fill with coke first, and as soon as that is warm to put the charge on the coke so that it comes to the bottom with the burning coke. A mixing of the charges with coal is not excluded, but is usually not necessary.

The process then continues as follows: The cover of one furnace is shut down, the slide drawn up, and the blast cut off. A suitable quantity of steam is now admitted which spreads itself over the glowing coke and penetrates downward through it, breaking up into its constituent parts, oxygen and hydrogen. The oxygen forms with the carbon of the coke carbonic oxide gas, while the hydrogen remains uncombined. The gases thus formed during their passage through the extremely hot coke themselves acquire a very high temperature, and at length pass by a channel into the third furnace, where the charge lies. The highly heated gases, carbonic oxide and hydrogen, act upon the charge, so that the first charge breaks up into a combination of sodium sulphide and aluminum sulphide, from which, by means of the second charge (sulphate of alumina), free metallic aluminum is formed. Passing into the melting zone the aluminum will melt, and, if it be drawn off, the flux added thereto will assist the fusion of the aluminum together; it is not, however, absolutely necessary. When the gases generated in the first furnace are too cool, the second furnace is closed by the cover, its coke having been kept hot by the blast, and the processes are repeated.

Instead of the bimetallic sulphide, pure aluminum sulphide may be employed, or a mixture from which it is generated, or, again, pure sulphide of soda, sulphide of potash, sulphide of copper, or other metallic sulphides or analogous compounds producing the same effect alone. In the latter case aluminum is obtained in combination with the metal of the sulphide. Instead of the one charge alumina + carbonate of soda + sulphur + coal, a mixture of alumina, sulphur, and coal only may be introduced; or further the sulphate of alumina may be replaced by alumina. The one charge may also be formed out of sodium sulphide, potassium sulphide, and other metallic sulphides, and the others may be produced from alumina or sulphate of alumina.

BEE-KEEPING IN INDIA.

IN September, 1881, Mr. John C. Douglas, of the Indian Government Telegraph Department, addressed the Secretary of State for India with a view to the introduction of bee-keeping into India. He pointed out that, as far as his inquiries went, the natives of India take honey and wax from wild bees only and he expressed the opinion that "as sweets form so important a constituent of the native dietary, there would be ample demand for honey for domestic consumption," and that "the climate is favorable to successful bee-keeping, and some of the plants extensively cultivated (*e. g.*, mustard) would yield honey in abundance. He further asked for any information which the Government might possess relating to past efforts in the same directions. Sir Louis Mallet answered that no information relating to the domestication of the Indian honey-bee had been received at the India office. In November, the Secretary of State forwarded the correspondence to the Government of India, with the remark that the subject appeared to him to be of sufficient practical interest to engage attention. Sir George Birdwood contributed a memorandum, in which he said: "The subject is of great interest, and likely to prove of no little importance if once seriously taken up in India. The bee has been more completely domesticated in India than in any other country, but only in the Himalayan regions; and in all the rest of India, the natives, as Mr. Douglas observes, take honey and wax from wild bees only, simply, I fancy, because cane sugar is so abundant." Sir George then referred to Moorcroft's account of the management of bees in Cashmere, and added:

"The bees in Western India, I may add, produce excellent honey, but the combs are practically inaccessible. Nothing, however, would be easier than to induce the bees of western India and, it may be presumed, of India generally, to yield their honey within reach, either by the European or the Cashmerian method of hiving them. In Ceylon also, according to Sir Samuel Baker, the bees are all wild." Mr. Douglas sent the following questions, which were issued with the rest of the correspondence by the Government of India, to the various local Governments and administrations:

"*A.* What quantity of honey is produced in India, and how is it disposed of? What price is realized on that sold or exported, and how is the remainder consumed? Is there any demand for honey, and is any imported?

"*B.* Are bees domesticated in any part of India, and is there any information available of the habits, yield, habitat, mode of harvesting, etc., of the wild bees? Probably the Forest Department would give valuable information.

"*C.* What are the varieties of bees indigenous to India likely to prove valuable if domesticated? Do they resemble the black, Italian, or other European variety, and how are the habits of the insect altered by the climate of the plains of India as compared with the habits of bees of colder climates?"

A large number of reports in reply from forest and district officers, and other persons who have paid attention to the subject, were received by the Indian Government, and these have been published in an official pamphlet.*

The following broad conclusions are drawn from the information thus received: 1. That several varieties of honey bees are found in every province of India where there is sufficient forest or jungle, and that the honey of some of the varieties is good and in considerable demand. 2. That efforts have been successfully made in the hills by Europeans to domesticate Indian bees, but that bee culture is only practiced by natives in the very rudest way. 3. That it is very doubtful whether the bee could be domesticated in the plains, owing to the dearth of flowers during the three or four months preceding the rains. 4. That in Southern India persons (Mr. Stormont, of Bombay, and others) have given up all attempts to domesticate the most common variety of bee found there, on account of its intractable nature. The Government of India arrived at the conclusion that "the industry is unlikely ever to be of great importance in India. It can only be followed in the hills, where flowers abound throughout the greater part of the year, or in the forests where food is equally plentiful. In the populous country of the plains, bee-keeping, as a general industry, seems impracticable." Opportunity will, however, be taken of the Calcutta International Exhibition to make some further inquiries on the subject.

The Rev. T. Mayer, of Bannu (Punjab), mentions five kinds of Indian bees. No. 1, the commonest and wildest, is a small black bee with (in the workers) a patch of orange on the anterior part of the abdomen; it builds one comb on the branch of a tree, and has a very venomous sting, but this is compensated for by the delicious purity and flavor of the honey. No. 2 is like the English bee, only a little more yellow; it is rare, and builds in hollow trees. No 3, from Waziri land (Makin), is very large; but No. 4, seen about Lucknow and Delhi, inside high arched gateways, is probably the largest bee in the world, and its comb contains over a hundredweight of honey. No. 5 is described by the natives as living in the ground. The lizards, frogs, tarantulas, and chocolate and yellow hornets are deadly enemies to the bees; ants also are troublesome, notably the large black ant and the white ant.

There are, it is believed, six sorts of bees in Southern India, but none of them have been domesticated. The honey and wax are sold in pretty bazaars, and locally consumed. The largest species make their combs on rocks, where they are taken by the wild tribes by the aid of smoke, and ladders made of creepers, etc. These bees are dangerous, and have killed men and horses; but others which build in boughs, in eaves of houses, and in the trunks of trees, are inoffensive.

There are nine kinds of bees in Burmah, of which five only are honey-producing. The largest bee is the *Pyagyee*, which measures over half an inch in length; it has yellow sides and dark back, with yellowish-brown wings, and stings when disturbed. It places its hive under large horizontal branches of trees. These hives are three to six inches wide and nine to eighteen inches long, often extending two feet on the branch.

Mr. W. Hill reports that a light black bee, with light gray wings, about the size of the common English fly, is domesticated by villagers in several parts of Coorg. The quantity of honey produced in Coorg may be roughly estimated at 25,000 lb., of which 14,000 lb. is from domesticated and 11,000 lb. from wild bees. The price realized for the former averages three annas the pound, and for the latter, which is of inferior quality, two annas the pound. The wild bees are most valued for the wax which they produce. The price of the best wax is eight annas eight pie the pound, and that of the ordinary quality five annas nine pie the pound. Mr. Carroll, Forest Ranger in charge of South Canara Forests (Madras), reports that the quantity of honey produced in those forests averages about 60 maunds annually, and from 80 to 100 maunds once in ten years, when the *coorji* plant is in blossom. The selling price within the district varies from two to three and a half rupees per maund, while the price of that exported is from four to five rupees per maund. The Deputy Conservator of Forests, Arakan, British Burmah, in describing the enemies of the bee, says that man is its chief enemy. Whenever a villager happens to stumble upon a hive in the jungle, he proceeds to appropriate its contents as soon as convenient. The only exception is made in the case of the species which does not yield honey during the rains. The *pyagyee*, however, yielding most honey and wax, has no natural close time, and no protection whatever except its sting. Its large hive on the branches of trees is more readily remarked than are the abodes of the species who settle in the hollows of trees, posts, etc. The *pyagyee* yields from half a seer of honey per hive to twelve seers (765 tolas) in exceptional cases. The pot of twelve seers is sold for three rupees. In the twenty-four Pergunnahs (Bengal) honey is collected in considerable quantities from the Sunderbunds, but no statistics are kept. Roughly speaking, the annual yield is put down at about 13,000 maunds, or 1,040,000 lb. Bees are not domesticated anywhere in the twenty-four Pergunnahs, and honey and wax are gathered from wild bees in the jungles. It is said that wild honey is produced in such abundance in the Sunderbunds that the domestication of bees would scarcely pay. In the Darjeeling district (Bengal) bees are half domesticated. Mr. E. R. Durnford writes: "The bees are usually started by a queen (or as they call her 'the Rajah'), accompanied by her bees, coming voluntarily to a house, and swarming on, or close by, the house. She is easily recognized, owing to the loud noise which she makes. She is usually, together with the bees, enticed into a box or hollow trunk cut into two pieces and made into a box, which is then placed near her swarm; if necessary, a little honey is smeared on the box and round the hole, which is, of course, left in it."

These few references to the contents of the various reports on the subject of bee-keeping throughout India will be sufficient to show how much information is contained in this important collection of papers published by the Government of India.—*Journal of the Society of Arts.*

* A Collection of Papers on Bee-keeping in India. Calcutta, 1883.

WHEN TO TRANSPLANT TREES.

"WHEN is the best time to transplant trees?" is a question that we are frequently asked by readers of the *Farmer*. If the inquiry is concerning peach and cherry trees, we should unhesitatingly say that spring is the better season, and for any tree there is no better time than spring; but the time may be so short between the opening of the ground and the starting into growth, that if there is a large amount of transplanting to be done there will not be time enough in which to do it. It is for the interest of nurserymen and tree dealers to make their customers believe that the *present* time, whether it be spring or fall, is the best, and in a certain sense this is true, for the "present" is the only time we can be sure of. So if one is ready in the fall, the fall will be the best time, except for the more tender varieties, like the peach, apricot, or cherry, and perhaps some of the evergreens.

How the work is done is of far more consequence than *when*. Visitors at the Connecticut State Fair were shown a large collection of fruit trees and shrubs from the nurseries of Stephen Hoyt & Sons, New Canaan, which were in perfect condition for transplanting on the 18th of September. The collection included apples, pears, plums, cherries, peaches, and many varieties of shrubs. The growth had stopped and the leaves were all stripped off by hand, leaving the wood plump, sound, and well ripened. Trees treated in this way would be fit to set for a full month or six weeks, while, if the leaves had not been stripped, the limbs would have shriveled badly during removal, unless the work was done without much delay.

In fall planting it is desirable to do the work early, so that the earth will have time to become well settled around the roots before freezing weather. On fall set trees the wounds from cut or broken roots begin to callous over, and will be all ready to send out new roots in early spring, while spring set trees will be later in getting started. In fall setting it is particularly important that the tree be left firm, so that it will not be swayed about by the winds. A tree that is set loosely, so that a large cavity is liable to be made around the stem, into which water may run and freeze, is pretty sure to be killed before spring opens. Naked roots cannot withstand much freezing. As an extra protection against blowing and freezing, it is an excellent plan to throw up a conical pile of earth around the trunks of all newly set trees to brace them against the cold winter winds. These banks will also keep ice away, which sometimes does considerable damage.

Nursery men who thoroughly understand their business can transplant a tree at almost any season of the year. The winter is often recommended for removing large trees. A trench is dug all around the tree, leaving a ball of earth no larger than can be drawn by a team on a sled. The trench is filled with straw or horse manure, and when the ball of earth is frozen solid the contents of the trench are removed, the tree pried over and loaded, by pulleys or otherwise, and hauled to the place where it is to grow, a suitable hole having been dug before the ground froze. If the earth could be packed as solid around the tree as it was before removal, it would be pretty sure to live, even though a large proportion of its roots were cut off. Do the work well, and the time of doing it will be of secondary importance.—*N. E. Farmer.*

THE BOTANY AND GEOLOGY OF THE COUNTRY BORDERING THE RIO GRANDE, IN TEXAS AND CHIHUAHUA.*

By PROF. JOHN S. NEWBERRY.

HAVING recently spent some time in Southern Texas and Eastern Chihuahua, a country until recently overrun by the Comanches and Lepans and hence but imperfectly known, I venture to hope that a few words of description of its aspects, geological structure, botany, and resources may not be unwelcome, especially as the attention of our people is being drawn in that direction, since it offers a new field for our surplus population and for the investment of capital.

The eastern and central portions of Texas are so well known as to require no detailed description. Near the Gulf the climate is warm and moist, and sugar and cotton are successfully raised. Beyond this belt, we pass on to plains on which there is little timber but mesquite, but the surface is covered with rich grass, and it is already one of the most productive grazing districts of the United States. The underlying rocks are, for the most part, of the cretaceous formation, without useful minerals, and the climate is dry.

On the western side of these plains, the country is traversed by mountain-chains, which belong to the Rocky Mountain system and which form the outer rim to a region of which the topography is more varied, the mineral resources are greater, and the agricultural capabilities are less than those of central or eastern Texas. This is, in fact, part of a great table-land, that fills the interval between the eastern and western mountain ranges, here nearly a thousand miles apart, which extends with diminished breadth southward throughout the central portion of Mexico. The Rio Grande has cut deeply into this plateau, and, where it has forced its way through the mountains that form its eastern rim, has excavated a series of deep and rocky cañons, which are impassable by boats and rival in their wild scenery those of the Colorado of the West. The country immediately bordering the river is much broken, but north and south there are intervals between the numerous and disconnected mountain-ranges, which are grassy plains, presenting on a smaller scale the features of the Llano Estacado on the north, and the Bolson de Mapimi on the south.

Further west, we reach a still more broken and arid country, in New Mexico, Arizona, Chihuahua, and Sonora, where the ragged outlines of the mountains and the peculiar vegetation —mostly cactus—gave a special aspect to the scenery. This latter country, the home of the Apaches, has been the theater of active mining operations for many years and the scene of unnumbered bloody tragedies. The country lying within southwestern Texas, eastern Chihuahua, and western Goahuila, less rich in gold and silver, seems not to have proved sufficiently attractive to the Mexicans to induce them to brave the danger of its occupation, and it has been not only unoccupied, but much of it unexplored. The line of the Mexican Central Railway, which is being pushed southward from El Paso to the city of Mexico, passes about 200 miles west of the belt of country referred to; and the railway which crosses the Rio Grande at Laredo, and is now extended southwest to Monterey and Saltillo, is about as far away on the east. A concession has been granted by the Mexican Government to European capitalists to build a road from Presidio del Norte or Eagle Pass, or both, to Topolovampo, on the Gulf of California, and this road will probably traverse almost centrally the district under consideration. The general altitude of this country is from 4,000 to 5,000 feet, the Rio Grande, as it passes through it, falling from 3,000 to 1,000 feet above the sea level.

BOTANY.

The country bordering the Rio Grande, in Chihuahua and Texas, is nearly destitute of trees, a feature which marks the aridity of the climate; yet, in certain localities, as on the bottom lands of the Rio Grande and Rio Concho, a vigorous and somewhat varied forest-growth was found at the advent of the whites. No better illustration of the relation between the kind of vegetation and the water supply in a country can be found, than that afforded by the luxuriant growth of trees of several kinds along the Cibola in the Chinati Mountains, Texas; while on all sides this oasis is surrounded by an apparently boundless, grass-covered prairie, where the rain-fall is inadequate for trees. On the mountain-summits, south of the Rio Grande, is a sparse growth of piñon (*Pinus edulis*) and evergreen oak (*Quercus Emoryi*). The lowlands, in certain localities over thousands of acres, are thickly set with mesquite (*Prozopis glandulosa*), here a strong, spreading shrub, never a tree, but with roots disproportionately large, composed of very dense tissue and furnishing a large amount of excellent fuel. Along the arroyos, cottonwood may occasionally be seen, either the narrow or the broad-leaved forms (*Populus monolifera* or *P. angustifolia*), and more commonly the hackberry (*Celtis occidentalis*), and the nogal, the little black walnut (*Juglans rupestris*), the Mexican buckeye (*Ungnadia speciosa*), and the guyacon (*Guyacum Coulteri*). The drier portions, especially the gravel terraces bordering the Rio Grande, are frequently covered with the creosote plant (*Larrea Mexicana*, and *Tonquieria splendens*. The latter forms a cluster of fifteen or twenty canes, ten or twelve feet high, springing from the same root, and bristling with spines, an inch or more in length, of which the bases are in contact. Usually it is without leaves, and seems as though dead, but, for a brief interval in the rainy season, it is covered with small crowded obovate leaves, and from the summits of each stem springs one or more spikes of brilliant crimson flowers.

Among the shrubs which form the "chaparral" or thickets, the *Holacantha* is the most conspicuous, and *Salisaria* the most interesting. The former, as its name implies, is a mass of thorns which are often as large and strong as those of the honey locust. The branches and spines are covered with a green epidermis, which performs the functions of leaves, and, in the spring, these bear bunches of yellow flowers similar to those of *Berberis*. The *Salisaria* is a labiate allied to *Scutillaria*, and the seed is inclosed in a balloon-like capsule, similar to that of the balloon vine (*Cardios permum*), also found here and having the same function, namely, dissemination by the wind. Two species of *Acacia* and one of *Berberis* (*B. trifoliata*), all spiry, help to make the chapparal as nearly impenetrable as the thickets of cactus further west. We are here fairly within the confines of the cactus country, but not in its heart. Many species differing much in habit are constantly in sight—the "nopal," an *Opuntia*, being the most common, one species growing in a mass ten feet or more in height, with each leaf-like subdivision of the stem a foot in diameter. Though covered with spines, this plant is largely eaten by cattle, and nothing is more common than to see a patch of it trampled down, half eaten, and the flattened stems notched by their semicircular bites. One species or variety of *Opuntia*, growing abundantly in Chihuahua, is of a deep purple color, which makes it conspicuous and often ornamental.

The most striking feature in the botany of this region is formed by the century plant and its allies; other species of *Agave*, *Habranthus*, and *Dasylirion*, and the yuccas. In many places these are the only plants attaining any large size, and are very numerous, scattered over the plains and slopes of the mountains; the plants not crowded, but separated by intervals of a few feet, which are occupied with a luxuriant growth of gramma grass. The yuccas belong to four species or three species and two varieties, *Yucca angustifolia* and *Y. saccata*. Of these, two rise to the height of five to fifteen feet, with trunks from six to twelve inches in diameter, the crowded radiating leaves crowning the summit in a round or oval mass, six feet or more in diameter, the old leaves hanging perpendicularly and forming a peculiar thatch around the trunk and extending to the ground.

The century plant is in Chihuahua represented by a variety with shorter and broader leaves than that commonly cultivated. From the center of the tuft, the flower stalk rises from 10 to 25 feet in height, composed of woody tissue and standing some years after bearing flowers. These persistent flower stalks, crowning the ridges and visible for miles, give a peculiar aspect to the scenery. The century plants are, however, nowhere as numerous as the species of *Dasylirion*, with which they are associated, and which do not die with the effort of florescence. Further south, the agave supplies from its sweet juice the material from which an intoxicating drink is produced. In this region, however, an alcoholic beverage is obtained from the "Sotol" (*Dasylirion Texanum*), which, from its abundance and the use made of it, deserves a prominent place among the economical plants of the country. Hundreds of thousands of acres are covered with this Sotol, and it would seem that it might be much more largely utilized than it is, for the manufacture of alcohol. The leaves are three to three and a half feet long by one and a half inches wide at the base, straight, flat, and garnished on either side by strong recurved hooks. The color is yellow green, and the leaves are very numerous. From the center rises, at a certain stage of growth, a woody flower stalk, ten feet high and at the base as large as one's arm. The trunk rises but a few inches above the ground and is completely concealed. The top of this trunk, composed of the closely imbricated leaf bases, which are broad, yellow, shining, succulent, and sweet, with a pulpy mass at the center, containing much saccharine matter, raw, or better roasted, is palatable and nutritious; so much so, that in the country where it grows it is said the Indians never really suffer for want of food, as this affords them an abundant if not varied aliment.

In the preparation of Sotol whisky—a liquid called *mescal*, as is also that made further west from other plants the portion of the plant which has been described is trimmed so as to resemble a head of cabbage, then roasted and fermented, the product of the vinous fermentation being distilled in the ordinary way. For roasting the Sotol, a pit is dug, some ten feet in diameter and four feet deep, lined with rude masonry. In this a fire is built, and when it has been burned down, the pit is filled with several hundred Sotol heads. When roasted, they are chopped in pieces and fermented in vats.

Another interesting plant, the companion of the Sotol, is the "Lechuguilla" (*Agave heterocantha*), of which the leaves furnish a strong fiber, universally employed for ropes, sacks, etc., in Northern Mexico. This grows on the mountain slopes, generally at an elevation of about 4,000 to 5,000 feet, is common in all northern Chihuahua, and especially abundant on the Chinati Mountains in Texas.

GEOLOGY.

The prevailing rocks of Chihuahua and Texas are cretaceous sediments, chiefly limestones, broken through at frequent intervals by eruptions of trap of various kinds, trachyte, porphyry, diorite, etc. Presidio del Norte is surrounded by mountains, partly eruptive, partly upheaved sediments, with open intervals between them, occupied by the cretaceous strata, generally much disturbed. Between Presidio and the Sierra Rica, the middle and upper cretaceous rocks prevail—apparently the Colorado and Laramie groups, the lower shales with bands of calcareous concretions filled with fossils, the upper sandstones and shales containing impressions of plants and thin coal. The concretions referred to above contain immense numbers of well defined cretaceous fossils, consisting of *Ammonites*, *Nautilus*, *Helicoceras*, *Ptychoceras*, *Baculites*, *Gryphea*, *Ostrea*, *Inoceramus*, etc. The Colorado shales here are very black, though much metamorphosed, and containing *Inoceramus*, form the walls of the vein of the Sierra Rica mine, a clean cut fissure, crossing the bedding of the shales nearly at right angles, having a quartz gangue, containing some very rich but very compound ore, copper, zinc, lead, silver, and iron.

Seventy-five miles southeast from Presidio are the San Carlos Mountains, composed of cretaceous limestones set at a high angle and very much metamorphosed. The San Carlos Cañon cuts through the greater part of the range, showing a section of several thousand feet of rock, mostly light blue, but sometimes black limestones highly metamorphosed, yet often crowded with characteristic cretaceous fossils.

The ore deposit at the San Carlos mine is of extraordinary magnitude and of special interest. It fills a series of chambers in limestone, one of which is several hundred feet in length and more than 200 feet in depth and breadth. It is evidently a chemical deposit, filling cavities made by solution, and consists of black, often crystalline, magnetite, pyrites, galena, and blende, containing both gold and silver. Of this ore there are apparently many millions of tons, and in character it is, so far as I know, without parallel among all the ore deposits of the country. At a distance of half a mile, the limestones are cut through by a great dike of diorite, which has doubtless furnished the heat that was the mainspring of the chemical affinities, but it has apparently contributed nothing to the mineral matter of the ore deposit. At a point further south, the dike crosses the zone of limestone which holds the ore. It is there metamorphosed, but not at all mineralized.

In the same region are other mineral deposits, which will probably prove to be of considerable value. Among these is another series of chambers in limestone, filled with hard carbonate of lead and galena. Others still, which are rich in copper, also carry silver and gold.

* Abstract of a paper read before the N. Y. Academy of Sciences, 1883.

MISSISSIPPI has 1,731 factories, working 5,941 hands, with a capital invested of $4,501,714, paying annually in wages $1,579,428, and yielding annually in products $8,154,758.

THE SUN'S DISTANCE.

AT the recent meeting of the British Association, Professor Robert Stawell Ball, LL.D., F.R.S., Andrews Professor of Astronomy in the University of Dublin, and Royal Astronomer of Ireland, delivered a discourse on "Recent Researches on the Distance of the Sun." He said:

It seems not unlikely that in early ages the distance of the sun was one of the very first astronomical problems which ever attracted speculation. In modern times, as the problem has gradually approached solution, the interest attached to it has gradually increased until it has culminated in the last few months by the occurrence of the transit of Venus. The importance of this problem arises from the fact that the distance of the sun is the base line in terms of which almost every other lineal magnitude in astronomy is to be expressed. An accurate measurement of this base will infuse accuracy into all the other astronomical quantities which spring from it. When we have learnt the distance of the sun we can measure the bulk of the sun and his diameter, we can measure the great planet Jupiter or the rings of Saturn, and the scale of the whole solar system becomes known to us.

Again, when we attack the loftiest problem in practical astronomy, and seek to stretch a sounding line over the vast abyss which divides our system from the stars, it is the distance of the sun which we must use as our measuring rod. No pains should be spared to give to so fundamental a unit all the precision of which it is capable. Let us define accurately the magnitude to be measured. The actual distance from the earth to the sun is not constant. In these autumnal months the distance is rapidly decreasing. We are at this moment drawing nearer and nearer to the sun at the rate of a thousand miles an hour. Next Christmas we shall be about a million and a half miles closer to the sun than we are to-night. At the commencement of the New Year we shall begin to recede. Next midsummer will find us as far from the sun as possible; then we shall draw in again, arrive next autumn where we are this autumn, and commence anew the cycle of changes I have indicated. Though these changes amount to millions of miles, yet they are at the utmost only a small fraction of the sun's distance. To superficial observation the sun always seems the same size, and hence there can be no great relative changes in its distance. There is no difficulty in understanding what is meant by the average distance of the sun. To express the idea with precision we may borrow the language of mathematics, and say that the distance from the earth to the sun consists of two parts—a large constant part and a small periodical part. The important problem, and the difficult problem, is the measurement of the large constant part. This is the question to be discussed in my lecture this evening.

HISTORY OF EFFORTS IN MEASURING.

The early history of the subject is as easy to sketch as the latter part is difficult. For 14 centuries the doctrines of Ptolemy were adopted on the distance of the sun as on all other astronomical problems. The method of Ptolemy might have succeeded if the sun's distance could have been measured by thousands of miles instead of by tens of millions. As matters stand, Ptolemy's method was utterly inadequate to cope with the real difficulties of the question. It led him to a conclusion which we now know to have fallen far short of the truth. The real distance of the sun is twenty times as great as that which Ptolemy deduced from his observations. But Ptolemy's result was a great step in advance, notwithstanding the tremendous error by which it was vitiated. It was, at all events, an honest attempt to solve the problem by a direct appeal to nature, and he succeeded so far as to demonstrate the great truth that the sun is larger than the earth. It is somewhat remarkable that the first reasonable approximation to the sun's distance was obtained by what can only be described as a well-considered guess.

The illustrious Huyghens, in the 17th century, hazarded a speculation which seemed plausible at the time, and which we now know to have been reasonably correct. Huyghens compared the diameter of the planet Mars with the sun. He compared the diameter of Venus with the sun. The primitive instruments used were capable of making these measures with some accuracy. Huyghens knew that the earth was also a planet revolving outside the path of Venus and inside that of Mars. Was it not reasonable to assume that the bulk of the earth might be comparable with that of its fellow planets, and intermediate between the bulk of Venus and that of Mars? This assumption—and, of course, it was no more than an assumption—gave the means of guessing the distance of the sun, which was concluded to be about 100,000,000 miles. When guesswork came to be replaced by measurement, this estimate of the sun's distance was corrected. It was found to be too large. It was amended first to 95,000,000 miles, then to 91,000,000 miles. This was subsequently found rather too small, and it is now generally thought that the sun's distance must be more than 92,000,000 miles, but hardly so much as 93,000,000 miles. We have here a range of one million miles.

The problem in its present condition can now be distinctly stated. We require to determine the sun's distance accurately to within 100,000 miles, or, to speak in round numbers, we desire to determine the distance of the sun accurately to one-thousandth part of its total amount. Is such a degree of accuracy obtainable? I believe that it is. I do not say that the problem has already been solved with this precision, but an approach has been made, and enough has been done to show that the accuracy I have indicated may be attained. But this margin is not really large when we reflect on the stupendous magnitude of the sun's distance. A favorite illustration in books of astronomy states that a journey to the sun in an express train running night and day without stopping would consume about 300 years. Before entering on such a journey it would, however, be well to recall to mind a very interesting lecture on railway accidents delivered by Sir F. Bramwell to this association a few years ago. From the figures available he showed that, supposing a man made up his mind to be killed by a railway accident, it would usually be necessary for him to travel day and night by express trains for 900 years before he could be quite certain of achieving his purpose. One or two return trips to the sun would no doubt suffice.

There are certain conditions which any method of measuring the sun's distance must fulfill. In the first place it is obvious that we cannot measure the distance directly. We cannot take a tape and measure it as we would the length of a field. We are compelled to resort to indirect methods. In other words, instead of measuring the sun's distance directly, we measure something else, from which we derive the sun's distance by calculation. Whatever that something else may be, there is one obvious condition which must be fulfilled. The method by which the calculation is to be

made must be absolutely unimpeachable. The measurable quantity and the sun's distance must be connected together by inexorable logic. The theory may be difficult, but it must contain no trace of ambiguity or of indefiniteness. No question of mere judgment or of estimation should be admissible. The connection between the two results must be as tight as a demonstration in geometry. Another condition, alike obvious and important, must be specified. Whatever be the measurable quantity, be it the displacement of a planet, a lunar inequality, or the coefficient of aberration, our measurements are subject to error.

Sometimes the measured quantity will be too large, sometimes it will be too small. It is necessary to have an organized plan of symmetrical measurement, so that the number of measurements which are too great shall be as nearly as possible equal to the number of measurements which are too small. This condition is secured by forethought on rearranging the details, and by vigilant suspicion of error from every conceivable source. The observations or measurements can then be purged from error, by the well known method of taking the mean. The success of this operation depends upon the number of observations that have been accumulated. It is therefore desirable that any proposed method of finding the sun's distance should admit of repeated application. Once we are assured that the observations contain no predisposition to be all too large, or all too small, the mean will afford a result vastly more accurate than the original observations. It will do more than this; it will tell us not only what the result is, but how far that result is entitled to our confidence.

Let me venture on an illustration to show how accuracy may be obtained from the mean of inaccurate results. Suppose the question were to be asked this evening—what o'clock is it? and suppose that every lady and gentleman were at the same moment to look at their watches, we should have, I suppose, a thousand watches or so brought to bear on the question. Perhaps I am not wrong in supposing that, if the trial were made, the thousand watches would exhibit some degree of variety. Some, no doubt, would be right, some would be a minute or two wrong, some, perhaps, would be five minutes wrong, or even more. But though there may be a general tendency in watches to be wrong, I believe no one can assert that as a whole they exhibit any particular preference to being fast rather than slow. There are, perhaps, some hundreds of watches in the room more or less fast; and there are probably an equal number of hundreds more or less slow. This is precisely the state of affairs that every astronomer likes. He would, under such circumstances, tolerate even watches that were very far wrong.

It is quite possible that one or two of the watches present may have stopped altogether; they were not wound last night, or the spring is broken. Shall we then exclude such watches when we proceed to take the mean? It is unnecessary to do so. Even if a watch were five or six hours behind time, it would only make the mean slow by about one-third of a minute, and in all probability this would be compensated by some other watch several hours too fast. The principle is sufficiently obvious. Each watch represents a more or less accurate attempt to tell the time. There is no particular bias for the watches to be fast rather than to be slow, and the greater the number, the more accurate will the mean be. The moral is obvious. If we wish to determine the sun's distance, the method employed must admit of a very large number of measures being made. Half are to be too large, half are to be too small, and the mean of all will afford a result which may be relied on. The various considerations I have brought forward may be considered to merge in the general condition that any proposed method must admit of the determination being made to within a thousandth part of its total amount. With this canon of criticism I shall briefly review the various methods in use, and in doing so, I am glad to acknowledge how much I have profited by the labors of Mr. Gill, Her Majesty's Astronomer at the Cape of Good Hope, who has, with characteristic energy, devoted himself to the discussion of this problem.

It has often been observed that at a meeting of the British Association the proceedings assume a certain tone in harmony with those branches of science with which our President for the time being has been specially identified. In recognition of this principle, which is both useful and appropriate, the first method which I shall allude to this evening is the exquisitely beautiful mathematical calculation by which the distance of the sun can be elaborated from ordinary observations of the planets systematically conducted at our national observatories. This method was foreshadowed in the dynamical theory of Newton, and was wrought to perfection by Leverrier. It is based upon the great law of gravitation, and is intimately connected with the splendid discoveries in planetary perturbation which form so striking a chapter in modern astronomical discovery. There is a certain relation between two quantities, which, at first sight, seem quite independent. These quantities are the mass of the earth and the distance of the sun. It follows from the measurements of the intensity of gravitation on the earth's surface and from the known revolution of the earth around the sun that the sun's parallax has a determined ratio to the cube root of the mass of the earth. There is no uncertainty about this result, and the consequence is obvious.

If we have the means of weighing the earth in comparison with the sun, then the distance of the sun can be immediately deduced. How, then, are we to place our great earth in the weighing scales? This is the problem which Leverrier has shown us how to solve, and he does so by invoking the aid of the planet Mars. If Mars in his revolution around the sun were solely swayed by the attraction of the sun, he would, in accordance with the well known laws of planetary motion, follow for ever the same elliptic path. At the end of one century, or even of many centuries, the shape, the size, and the position of that ellipse would remain unaltered. Fortunately for our present purpose a disturbance in the orbit of Mars is produced by the earth. Although the mass of the earth is so much less than that of the sun, yet the earth is still large enough to exercise an appreciable attraction on Mars. The ellipse which Mars follows is not always the same. The shape of that ellipse and its position gradually change, and the position in which the planet is found depends upon the mass of the earth.

The place in which the planet is found can be determined by observation; the place which the planet would have had if the earth were absent can be found by calculation. The difference between the two is due to the mass of the earth, and when it has been measured the mass of the earth can be ascertained. The amount of displacement increases from one century to another; but, as the rate of growth is small, ancient observations are necessary to enable the measures to be made with accuracy. A remarkable occurrence, which took place more than two centuries ago, enables the place of Mars to be determined with great precision. On the 1st of October, 1672, three independent observers witnessed the occultation of the star ϕ Aquarii by the planet Mars. The place of the star is known with accuracy, and hence we are provided with the means of accurately defining the point on the heavens occupied by Mars on the day in question. From this result, combined with the modern meridian observations, we learn that the displacement of Mars by the attraction of the earth has in the lapse of two centuries grown to about five minutes of arc (294 seconds). It has been maintained that this cannot be erroneous to the extent of more than a second, and hence it would follow that the earth's mass is determined to one three-hundredth part of its amount. If no error were present, this would give the sun's distance to about one nine-hundredth part, which approaches very closely to the limit we have indicated.

Notwithstanding the intrinsic beauty of this method, and the very high auspices under which it has been introduced, it will, I think, hardly be found to fulfill all the needful conditions. We make no impeachment of the fidelity of the observations, and we feel no doubt that the displacement of the planet is mainly, if not entirely, due to the disturbing effect of the earth's attraction; but it seems quite impossible to be sure that some other cause, minute though it must be, may not also have contributed to the result. We cannot be absolutely sure that the theory is above suspicion. Interesting and beautiful though this method may be, we must rather regard it as a striking confirmation of the law of gravitation than as affording an accurate means of measuring the sun's distance. Several other methods have been employed by which we can place the earth in the weighing scales. Perhaps none of these methods is free from objection as a means of measuring the sun's distance. I must, however, mention one of them which has special claims upon our attention of a very peculiar kind. This time we invoke the aid of that erratic member of our system known as Encke's comet. The picture here shown contains a sketch of a portion of the solar system. We find in it first the sun at the center, then the orbit Mercury as a circle surrounding the sun, then comes the orbit of the earth, while the outermost circle is the orbit of the great Jupiter.

Besides these three paths, all nearly circular, we have also a highly eccentric ellipse which represents the path pursued by the celebrated comet which bears the name of Encke. The comet completes a circuit around its ellipse in a period but little more than three years. It does not, however, move with uniform velocity. Around this remote part of its path the comet creeps languidly; but as it turns round and commences to approach the sun the pace gradually improves, and the comet itself swells up in dimensions and in splendor. Encke's comet, although so famous, is one of that numerous host of telescopic objects which seldom or never become bright enough to be visible to the unaided eye. It can only be seen when comparatively close to the sun. All around the outer part of its path it is totally invisible in the most powerful telescope. The comet itself is shown here. It is a dull, hazy spot of light, evidently composed of materials of filmy, or almost spiritual texture. A great comet is usually attended by a long tail. This small telescopic comet is not so decorated. Notwithstanding the insignificance of Encke's comet, it is capable of giving us very interesting information acquired during its somewhat eccentric travels through the solar system.

It is, for instance, able to weigh the earth, and thus to afford the means of measuring the sun's distance. The elliptic path which the comet describes is, of course, mainly due to the preponderating influence of the sun's attraction. If there were no source of disturbance, the comet must follow that ellipse inflexibly and never deviate therefrom. But the planets insist on asserting their power, the orbit of the comet is disturbed, and that orbit is so eccentric that the disturbances occasionally attain to enormous dimensions. For instance, when the comet draws near the sun it passes very close to the track of Mercury. It has happened that the comet arrives at Mercury's orbit at the same moment that Mercury arrives at the comet's orbit. Such a *rencontre* may bring the comet and the planet within a couple of million miles, which is quite an insignificant distance in measures of this description. In such a case the comet and the planet attract each other with vehemence. The solid mass of Mercury drags the comet from its path, though the flimsy and unsubstantial comet can impress no measurable disturbance on the movements of Mercury. In its outward career the comet sometimes approximates to Jupiter, in which case the great planet contributes its potent aid to the derangement of the comet. The earth, also, although its path lies more distant from the track of the comet, is still able to contribute a little further disorder, so that the path which the comet really pursues is one of amazing complexity.

It is the task of the astronomer to survey that path, to determine its shape and its position, and to ascertain the epochs at which the comet accomplishes each successive stage on its never ending journey. This work being done, the problem is now one for the mathematician. It is for him to decompose the complicated movement into its constituent elements. He discriminates first the great elliptic motion due to the attraction of the sun. Superimposed on the elliptic motion he finds the smaller and more perplexing movements due to the planetary disturbance. He can disentangle the effect due to the earth's attraction from that due to Mercury and to Jupiter. This work has been done in a masterly manner by the late distinguished Russian astronomer, Von Asten, and he has elicited the mass of the earth from a most recondite inquiry, embracing some twenty complete revolutions, during which the comet has been observed. It would, however, be unwise to assign much weight to the distance of the sun which may be deduced from these researches. Notwithstanding the labors of many astronomers, the theory of the comet's motion is still not sufficiently perfect for this purpose. It cannot be pretended that this method would give the sun's distance to within a thousandth part, and accordingly this method must give place to those which have more claims to accuracy.

MEASUREMENT BY LIGHT.

One of the most celebrated methods of measuring the distance of the sun is derived from a combination of experiments on the velocity of light with astronomical measurements. This is a method of very great refinement and beauty, and although it does not satisfy all the necessary conditions, it is impossible in this lecture to avoid a brief reference to an investigation so remarkable. The principle of this method is easily enunciated. Though the velocity of light is stupendous, yet it has been possible to measure that velocity by experiment. The best determinations indicate that a ray of light would flash over a distance equal to seven times the circumference of the earth in a single second of time (300,400 kilometers). A ray of light would travel from Southport to London in about the thousandth part of a second. The dimensions of the solar system are, however, so considerable that even a sunbeam requires an appreciable interval of time to span the abyss which separates the earth from the sun. Eight minutes is approximately the duration of the journey. In fact, if the sun were to be suddenly blotted out, it would still be seen shining brilliantly for eight minutes after it had really disappeared.

Viewed as a means of measuring the sun's distance, it would be necessary to determine this interval accurately to half a second. Does astronomy hold out any prospect of our being able to measure this interval with such nicety? This question is intimately connected with two of the most brilliant discoveries in the annals of astronomy. Although they are well known to every one who has paid any attention to this science, yet I must refer to them briefly to examine how far they admit of the needful precision. Every one who has had the opportunity of using an astronomical telescope is familiar with the exquisite system of four moons which grace the great planet Jupiter. These little bodies led 200 years ago to the discovery of the velocity of light. In their frequent revolutions the little satellites plunge occasionally into the vast and dense shadow thrown by the mighty planet. The sun's light, which had previously rendered the little satellite a glittering point of light, is then cut off, the satellite becomes invisible, and we say that it is eclipsed. This is a most pleasing phenomenon to witness, and as the satellites revolve so rapidly, the eclipses occur with greater frequency. From the discussion of previous observations of the satellites we have become aware of the nature of their movements, so that the advent of eclipses can be predicted, and even the time of their occurrence. But the time at which the eclipse takes place is not identical with the moment at which we see the eclipse.

There is an old story of the French king who came to the observatory to see an eclipse; unfortunately his Majesty was late, the eclipse had passed, and when this was explained to him, he wanted to know if it could not be done over again. (Laughter.) The only way in which an eclipse could be done over again would be first to view the eclipse from Jupiter himself, and then, with the quickness of thought, to be transferred to the earth, from whence the very same eclipse would be seen a second time. As long as the little satellite is shining it radiates a stream of light across the vast space between Jupiter and the earth. When the eclipse has commenced, the little orb is no longer luminous, but there is, nevertheless, a long, slender stream of light on its way, and until all this has poured into our telescopes we still see the little satellite shining as before. If we could calculate the moment when the eclipse really took place, and if we could observe the moment at which the eclipse is seen, the difference between the two gives the time which the light occupies on the journey. At both extremities of the process there are characteristic sources of uncertainty. The occurrence of the eclipse is not an instantaneous phenomenon. The little satellite is large enough to require an appreciable time in crossing the boundary which defines the shadow, so that the observation of an eclipse is not sufficiently precise to form the basis of an important and accurate measurement. Still greater difficulties accompany the attempt to define the true moment of the occurrence of the eclipse as it would be seen by an observer in the vicinity of the satellite. For this we would require a far more perfect theory of the movements of Jupiter's satellites than is at present attainable. This method of finding the sun's distance holds out no prospect of a result accurate to the one-thousandth part of its amount, and therefore we may discard it. But there is yet another method by which the experimental determination of the velocity of light can be so combined with purely astronomical measurements as to yield the sun's distance as a result. Time will not permit that I should enter into this subject, which is identified with one of the most glorious discoveries of astronomy—namely, the aberration of light. But here I would only remark that this method does not fulfill the condition of geometrical necessity. It has not even the somewhat inferior attribute of dynamical necessity. The physical conceptions introduced may to some degree be open to question. Is it certain that the velocity of light in air must be the same as the velocity of light through space? Is it certain that the motion of the whole solar system can be suitably allowed for and eliminated? The time has not yet arrived when this latter question can be fully answered.

TRANSIT OF VENUS.

The most celebrated method of measuring the distance from the earth to the sun is without doubt that which is afforded by the transit of Venus. This has engrossed more attention than all the other methods together. On four occasions the attempt has been made to find the sun's distance by its aid; the last of these occurred only last December, and another opportunity will not occur until June in 2004. It was formerly supposed, and it is, no doubt, still maintained by many, that the transit of Venus is *par excellence* the method, but the growth of practical astronomy has tended to question the supremacy of the transit of Venus. An attack has been made in two distinct directions. It has on the one hand been shown that the transit of Venus is incapable of the accuracy that was at one time claimed for it. On the other hand the new method by the aid of the minor planets has arisen. The recent transit of Venus was observed in this country. It was on the 6th of last December, late in the afternoon, that the memorable event took place. The weather, it may be remembered, was in most places very unfavorable. A heavy snow storm prevailed over a great part of the country. At Dunsink Observatory, Dublin, where I reside, a more unfavorable morning could not well have been conceived. The snow was falling, the clouds were thick, and there did not seem to be the slightest chance that anything could be seen. The day before was tolerably fine, and we had a sort of rehearsal of the observations to be made. The large equatorial was directed to the sun, and it was followed to the horizon. As the sunset approached, the sun passed behind a tree and could not be seen. This was one use of the rehearsal; it showed that the tree was an obstacle. I pointed this out to the kind neighbor in whose grounds the tree was placed, and next morning the top was cut off.

On the eventful day, and up to about half an hour before, the commencement, there did not seem to be a chance that any observations would be obtained, but we placed everything in readiness as if the day had been perfect. Just before the critical moment the snow ceased, the clouds began to break, and though the commencement was missed, I enjoyed a beautiful glimpse of the planet when its disk had about half entered on the face of the sun. It was, however, but little more than a glimpse, for the clouds again gathered and the snow descended, giving me for a few moments an exquisitely beautiful telescopic picture of a snow storm, with the sun's

disk as a background. For an hour nothing could be seen. Then again the clouds opened and disclosed what I can only describe as a most beautiful and striking picture. The sun had commenced to put on the ruddy hues of sunset. Its disk was streaked with bands of cloud, and far in on the surface hung the dark body of the planet. It was one of those rare sights once seen can never be forgotten. A photograph of the sun with Venus in the act of transit is represented on the screen This gives a faithful picture of what the transit is really like. It is one of the pictures taken by Tennant in 1874 at Roorkee in India. Good fortune has generally attended the expeditions which last December were scattered far and wide over the earth to observed the transit of Venus. A map is prepared to indicate the various regions in which the different phases of the transit were visible. The British Isles are seen just to fall into the region in which the commencement of the transit is visible. In the eastern parts of Europe and the whole of Asia the entire is invisible.

The western hemisphere contains more favored regions. The most glorious views of the transit of Venus were those obtained in America. In the center of the region where the whole transit is visible lies the splendid empire of Brazil.

The only part of the American continent which was unfavorably situated was the British possessions at the North. We cannot now enter into details as to the method by which the transit of Venus is used for the purpose of finding the sun's distance. Every book on astronomy contains a description of the process. It will be my duty to attempt to define the amount of accuracy of which the method is capable. The observations to be employed are chiefly those made when the planet and the sun are apparently in contact, and the value of the method mainly depends on the possibility of determining the time with precision at which the contact takes place. It was at one time believed that exceptional accuracy was attainable in such observations. Experience has not shown that these expectations were well founded. Look, for example, at a photograph of the drawings made on the last occasion by one of the most skillful observers, Dr. Vogel. We have here six most beautiful views of the progress of Venus as it approached to the first internal contact. The two extreme observations are plain enough. At 3 hours 10-8 min. Venus had not entered on the face of the sun completely. At 3 h. 14-1 min. there can be no doubt that the critical moment had passed. There are four intermediate stages. The recorded time of contact is 3 h 13 min. 15 secs., but there must be a latitude of many seconds in the attempt to define a moment so confused. The chief reason of the difficulty arises from the sluggish motion of Venus.

The problem is something like trying to tell the time accurately on a watch which had no minute hand; but besides the difficulty from this cause there are other difficulties of a very special character. Venus is surrounded by an atmosphere. You see the atmosphere in the ring of light surrounding the planet in Vogel's picture. The sun's rays are refracted through this atmosphere, and they place the observer in a condition of very great embarrassment, for the edge of the sun is distorted at the moment of contact. Another source of difficulty arises from the phenomenon known as irradiation. Venus is a black spot; the sun is of dazzling brilliancy. This contrast has the effect of making Venus smaller than it ought to appear. A white circle on a black ground appears to be larger than a black circle on a white ground, even though both may really be exactly of the same size. The irregularities arising from this cause affect in a marked degree the observations of the transit of Venus. The difficulties may, to a certain extent, be removed by calling in the aid of photography. By photography, also, a large number of observations can be secured during the progress of the transit, and thus in some degree compensation is made for the rare occurrence of the phenomenon. A grand effort has certainly been made by the British Government, under the skillful direction of Mr. Stone, to give the transit of Venus a fair trial.

Expeditions were sent to the West Indies, to South Africa and Madagascar, to Australia and to New Zealand. The expeditions were, on the whole, very fortunate so far as the weather was concerned, and no doubt an approximate value of the sun's distance will be the result. I do not, however, believe that the transit of Venus can be expected to give that distance accurately to one-thousandth part. It is impossible to define the contacts with the precision that would be required. It was on the first night of the present century, a date very easy to remember, that the first of the minor planets was discovered; a few others were quickly added, and 40 years later the career of discovery was reopened. Fresh planets were added by units, by tens, and by scores, until at the present moment we recognize about 240 of these objects revolving around the sun in the gap between Mars and Jupiter. The sun, which controls the mighty planets of our system, does not disdain to guide with equal care the tiny globes which form the minor planets. Each revolves in an elliptic orbit, and at certain times some of them approach near enough to the earth to have their distances measured. The observations can be made with very great precision; they can be multiplied to any extent that may be desired. They can be discussed with geometrical accuracy, so that from them one result and only one can be deduced. In speaking of these planets as small objects, I must be understood to use the words in a comparative sense. They are small as planets, but perhaps the area of an average one might be comparable with that of a good-sized English county. The discoveries of minor planets have added enormously to the labors of those astronomers who compute the movements of the solar system.

PLACES OF THE MINOR PLANETS.

The task of predicting the places of the minor planets has been for many years most ably accomplished in the Berlin "Ephemeris." The editor must be some times alarmed at the daily extension of his list. Many of these bodies are of but little interest. Perhaps it would be no great harm to allow a good many of them to get lost again—(laughter)—and be no more followed by telescopes or computers. Some of these little bodies have, however, a great astronomical future. They seem destined to tell us more faithfully than Venus or than Mars what is really the distance from the earth to the sun. The very small ones will not answer; they can only be seen in very powerful telescopes, and they do not admit of being measured with the necessary accuracy It is also obvious that the planets to be chosen must be as near to the earth as possible. They should have orbits possessing a high degree of eccentricity, so that when in perihelion and in opposition simultaneously the approach may be made as close as possible. Under favorable circumstances a minor planet will approach the earth to a distance but little more than three-quarters of the distance of the sun. These various conditions limit the number of minor plants available for this purpose to about a dozen, of which one or two will usually be suitable each year. About two years ago Mr. Gill invited astronomers in the Northern Hemisphere to cooperate with him in the Southern in an attempt to apply this method to Victoria and to Sappho.

It became my duty to co-operate in this scheme so far as my opportunities went. As the planet pursues its course through the sky, and as the sky is everywhere studded ever with countless myriads of minute stars, it is evident that the planet itself so like a star will always have some stars in its immediate neighborhood. As the movements of the planet are well known, it is possible to foretell where it will be on each night that it is to be observed. The scheme was completely drawn up many months before the observations were to commence. Each observer who participated in the work was thus advised beforehand of the stars which were to be employed each night. Viewed from any part of the earth, from the Cape of Good Hope or from Great Britain, the positions of the stars are absolutely unchanged. Their distance is so stupendous that a change of place on the earth displaces them to no appreciable extent. But the case is different with Victoria. It is hardly one-millionth part of the distance of the stars, and thus the displacement of the planet when viewed from the Cape and when viewed from Europe is measurable. The measurements are made from a comparison star with a micrometer or a heliometer. The star is one beautifully defined point, the planet is another, and the difference of declination between the two can be measured with a high degree of accuracy.

Two comparison stars symmetrically placed with regard to the planet are usually employed, as a number of sources of error can be thus eliminated. The displacement of the planet is to be elicited by comparison between the observations in the northern hemisphere with those in the southern hemisphere. The observations must be made as nearly as possible at the same time, due allowance being made for the motion of the planet in the interval. Although every precaution is taken, yet the fact remains that we are obliged to compare the measures made by observers in the northern hemisphere with those made by different observers, and, of course, different instruments in the southern hemisphere. In this respect we are, no doubt, at no greater disadvantage than in the transit of Venus; yet it is possible to obviate even this difficulty, and thus to give the minor planet method a great advantage over its rival. The difficulty would be overcome if we could conceive that an observer and his observatory, after making a set of observations on a fine night in one hemisphere, were to be transferred, instruments and all, to the other hemisphere, and there to repeat the observations. This problem can be solved without any miraculous agency, and in it we have undoubtedly the most perfect mode of measuring the sun's distance with which we are acquainted. This method has already been carried out with success by Mr. Gill in the case of Juno, but there are other planets more favorably situated, and the work can be done for a mere fraction of the expense of the much more cumbrous transit of Venus. Take, for instance, one of the little planets which sometimes approach to within 70,000,000 miles from the earth. When the opposition is drawing near, a skilled observer is to be placed on some suitable station near the equator. The instrument he is to use should be the heliometer. It can be used to measure stars at a greater range than is attainable with the filar micrometer.

The measurements are to be made in the evening, as soon as the planet has risen high enough to enable it to be seen distinctly. The observer and the observatory are then to be transferred to the other side of the earth.

How is this to be done? Say, rather, how you could prevent its being done. Is not the earth rotating around its axis, so that in a few hours the observatory on the equator is carried bodily round for thousands of miles? Before the morning dawns the observations are to be repeated. The planet is found to have changed its place very considerably with regard to the stars. This is partly due to its own motion, but it is also largely due to the parallactic displacement arising from the rotation of the earth, which may amount to as much as 20 seconds. The measures on a single night with the heliometer should not have a mean error greater than one-fifth of a second, and we might reasonably expect that observations could be secured on about 25 nights during the opposition. Four such groups would give the sun's distance to one-thousandth part. The chief difficulty of the process arises from the motion of the planet during the interval which divides the evening from the morning observations. This, it must be admitted, is a drawback to the method. It can, however, be avoided by diligent and repeated measurements of the place of the planet with respect to the stars among which it passes. Let us hope that long before another transit of Venus shall come round the problem will have been satisfactorily solved by the minor planets. It will surely be expected that I shall not close this lecture without an attempt to say what the distance of the sun is, so far as modern research has gone. Reviewing all the different methods, the most probable value seems to be 92,700,000 miles. It does not seem likely that this can be erroneous to the extent of 800,000 miles. The distance of the sun is one of the most important constants in the universe. It is indeed a constant in a very emphatic sense. The planetary perturbations which affect so many other elements of the solar system are powerless to touch this constant. Once the distance of the sun has been measured, the telescope with which the observations were made may moulder, and the astronomer who used it may survive only in name, but the work he has accomplished will remain true for countless ages of the future.

ALGOL, THE DEMON STAR.

AMONG the many interesting objects presented to our view in the evening skies of the close of the year, scarcely any are more interesting than the variable stars, so called on account of the periodic changes in their brilliancy. Our own sun is considered by astronomers as a variable star, with a period of about eleven years. This period is not only very long, but the difference in the amount of light given is too small to be appreciated by any but the most delicate photometric measurements. There are, however, about fifteen stars visible in northern latitudes which are sufficiently variable to present a very marked difference at certain times from their ordinary appearance. Some of these at their minimum disappear entirely from view, while others can only be seen in the largest telescopes. The most singular and interesting of all these variable stars, both on account of the very short period of time in which its changes are accomplished and the remarkable alteration in its appearance, is a star which now rises early in the evening in the northeast in the constellation Perseus. To this star the Arabs, many hundred years ago, gave the name Algol, meaning the Demon, their fantastic belief being that the star was the slowly winking eye of one of these objects of their superstitious fear who inhabited that portion of the heavens. Algol ordinarily presents the appearance of a star of the second magnitude, in which condition it remains for two days and fourteen hours. It then begins slowly to fade for about three hours and a quarter, when it sinks to the fourth magnitude. This appearance continues for about half an hour, when it begins to brighten, regaining its full luster in about three hours and a quarter more. The time occupied in the round of change from one minimum to another is a little less than two days and twenty-one hours.

As many of these minima occur during the day time, or at very inconvenient hours for observation, it is not often that Algol is observed at the interesting phase.

A favorable opportunity to watch the star will occur tomorrow, the 20th, when about three minutes past ten in the evening it will begin to fade, reaching its minimum of brightness at thirty-three minutes past one after midnight, at which time it will, to the eyes of many persons, be only just distinguished. A still more favorable opportunity occurs on the 23d, when it begins to fade at eight minutes to seven, reaches its minimum at twenty-two minutes past ten, and regains its full luster at eighteen minutes to two a. m.

A list of all the dates at which the minimum of Algol may be observed for the rest of the year is here presented, together with the time at which the star passes the meridian, at which moment in the latitude of New York Algol is almost exactly overhead:

Date of minimum.		Star on meridian.
September 26	7:11 p. m.	2:38 a. m.
October 11	3:15 a. m.	1:39 a. m.
October 14	0:04 a. m.	1:28 a. m.
October 16	8:53 p. m.	1:20 a. m.
November 3	1:46 a. m.	0:16 a. m.
November 5	10:35 p. m.	midnight.
November 8	7:24 p. m.	11:49 p. m.
November 23	3:28 a. m.	10:50 p. m.
November 26	0:17 a. m.	10:38 p. m.
November 28	9:06 p. m.	10:30 p. m.
December 16	1:59 a. m.	9:19 p. m.
December 18	10:48 p. m.	9:11 p. m.
December 21	7:36 p. m.	9:00 p. m.

Three hours and thirty minutes subtracted from the time given for the minimum gives the time at which the star begins to fade, which time, it is well to observe, will fall on the evening of the day before whenever the minimum is reached shortly after midnight. For instance, the waning phase of October 14, occurring four minutes past twelve a. m., begins on the 13th at thirty-four minutes past eight p. m. The same interval of time added gives the hour when the star will shine with its normal luster.

The observer must not forget that the star rises about four minutes earlier every evening, and, therefore, while it is now visible about two hours high in the northeast after dark, reaching the zenith or point overhead about three o'clock in the morning, it will at the end of the year be very high up when the sun sets, and reach the meridian about nine o'clock.

While Algol may be thus identified by noticing what bright star is exactly overhead at the hour given for the meridian passage, a better method of finding the star at the time when wanted is to draw an imaginary line from the little group of stars called the Pleiades, or Seven Sisters, to the constellation Cassiopeia, or the Lady in her Chair, which is well marked by five bright stars in the form of a W, and now visible in the northeast, very high up. Algol is situated on this line, about one-half of the distance from the Pleiades to the center of the W. At about eight o'clock on the 21st of September, and for some time afterward, the three objects named, Cassiopeia, Algol, and the Pleiades, are in a straight line from the zenith to the northeast horizon.

As to the cause of this singular and rapid variation in the amount of light emitted by the star, astronomers are not perfectly agreed, but the most generally received opinion, the theory that, on the whole, explains the phenomenon in the most satisfactory manner, is that Algol is attended by an enormous dark planet revolving at a very short distance from him in the period observed—that is, two days twenty hours and forty-nine minutes—thus eclipsing a very large portion of the star's light—about seven-tenths. In order to give an idea of how matters stand if this theory is correct, we will suppose Algol to be a sun of the same size and light-giving power as our own—that is, 860,000 miles in diameter. The planet is then 720,000 miles in diameter, and it revolves at a distance of about 5,000,000 miles from Algol. The planet is therefore over eight times the diameter of Jupiter, the largest in the solar system, and its distance from its primary is about one-seventh that Mercury is from the sun, Mercury being the nearest to the sun of any in the solar system.

However different this is from anything in the system of which our own sun is the center, both in the size of the planet and the enormous speed of its revolution in its orbit, it is not more wonderful than many things we know to exist among the stars, and it is the theory most generally accepted, as the character of the obscuration and the resumption of its brightness are precisely such as would be presented by the interposition of a dark body between us and the star, at intervals corresponding to the period observed.

It may not be amiss to remark that the list of Algol's minima may be extended by taking the exact hour of the observation of one, and then twenty days after another minimum will occur one hour and forty-two minutes later in the evening. If this should be inconveniently late, then take twenty-three days, instead of twenty, and one will occur one hour and twenty-nine minutes earlier than the hour of the one observed. This will appear on examination of the list given.—*"Royal Hill," in the Evening Telegram.*

TERRIBLE MINING WORK.

THE upraise from the 2,900 level has yet twenty feet to go to connect with the bottom of the winze down from the 2,700 level. The rock continues bitterly hard; besides, it does not blast well, breaking short and blowing out in pot holes. With all this a perfect torrent of hot water is constantly pouring down upon the men. It is difficult to conceive how they can work at all in such a place. They must go principally by the sense of touch—must feel their way like blind men. Not only is it impossible for the miners to look up, but such is the force of the pouring cascades of water that they cannot climb the ladders without danger of being beaten off; and it has been found necessary to rig a hoisting apparatus by which to hoist the men up to their work. In no other place in the world could be found miners possessing sufficient nerve to work in such a place. The Burleigh drill is kept several feet ahead to guard against the sudden tapping of the water standing in the winze.—*Virginia Enterprise.*

FISHING GEAR.

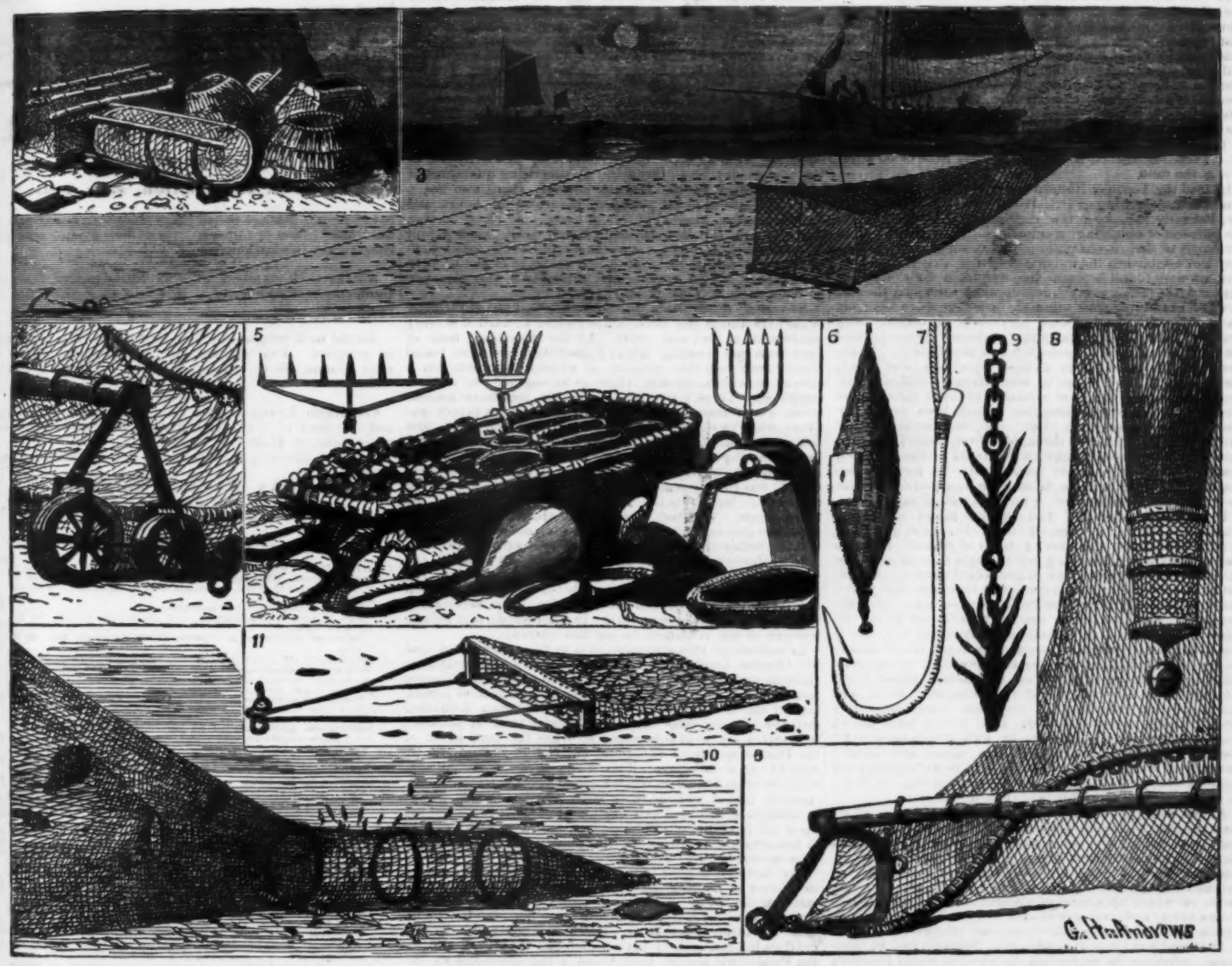
OUR illustrations this week from the International Fisheries Exhibition, London, display various articles of fishing gear shown in the department of British Sea Fisheries. Figure 1 represents a group of lobster-pots and crab-pots. There are innumerable contrivances in use for catching these animals. Sometimes they are circular wicker baskets; in other instances, nets extended by laths of wood or rods; and latterly sheet zinc and galvanized iron wire have been much used in their construction. But, whatever form be adopted in any locality, the object sought to be obtained is the same; it is to place a tempting bait in a species of cage, which the roving lobster or crab can see from the outside; the cage having one or more apertures through which the animal can enter, but so arranged that when inside its escape is prevented. These traps are laid at the bottom of the sea, generally on rocky bottoms, along the coast.

Figures 2 and 3 represent the method in ordinary use for catching sprats, and with some modification, and on a smaller scale, for taking whitebait. The plan adopted is called stow-boat fishing. The net used in this case is a bag or pocket net, which, when set, and in use, forms a long funnel about 150 feet in length, with a square opening or mouth 30 feet wide, and nearly of the same height. The bottom part of the net, at the mouth, is extended by a beam or "balk" of the same width as the opening. Another beam of the same dimensions, extends along the upper part. From a sheave beside the stem of the vessel a strong rope or chain is secured to the center of the lower beam, passing through a ring fixed in the center of the upper beam; this tackle is for lowering and raising the mouth of the net. The vessel, when about to take the fish, is brought to anchor; and when securely "brought up," the net is lowered below the bottom of the vessel; the lower beam is then let go, and the tide runs freely through the open mouth. To keep this steady and at right angles with the run of the tide, four ropes are so placed that they lead from the extremities of the beams to the vessel's anchor. The net being properly set, the vessel remains in that position during the whole run of the tide. As it is well known where the fish abound, the takes are generally good; sometimes enormous. The net is lifted by hauling upon the chain or rope secured to the lower beam; this brings the two beams together and closes the mouth of the nets, the bulk of the fish being congregated in the after end. This causes that part of the net to rise to the surface of the water, astern of the boat, and affords a fine opportunity for the birds to help themselves to their share of the catch. Birds are always numerous when shoals of sprats are on the move.

Figure 4 shows the invention of Mr. J. W De Caux, of Great Yarmouth. It is a trawl-beam carriage, having two wheels, a large one and a small one, attached to the trawl heads, the frames of which are modified for the purpose. The object of this invention is to allow the heavy trawl beam to pass more easily over the bottom upon which it is working. But it is possible that the continual passing of these wheels over the fishing ground may have an injurious effect However, it is one of those inventions, of the effect and usefulness of which we require more knowledge and experience than we at present possess to enable us to form an opinion as to its value.

Figures 5, 6, 7, and 9 represent various articles of fishing gear. Figure 7 is a cod-hook, the full size. Figure, 9 is a fisherman's creeper, used for recovering lines. nets, and ropes which have broken adrift. The particular specimen here represented is one hundred years old, and was much used on the Devonshire and Cornish coasts by smugglers for recovering contraband casks and bales, which they were obliged to hide occasionally under water.

Figures 8 and 10 show the trawl gear, beam, heads, and net. Trawling should now be understood by our readers, as the trawl-net, its construction and use, were minutely described in our pages on several occasions. But there is still a very important question to be settled, in regard to the use of this apparatus, and the judges at the Fisheries Exhibition will no doubt pay special attention to it. Besides the effect which the trawling apparatus has on the bed of the fishing ground, there is the destruction of immature fish, which are taken up by it and destroyed by being crushed in the cod-end, or tapered part of the net. There can be no doubt that a large quantity of small fish, of the better kind, are being continually destroyed in this way. In order to remedy this evil, there are several very ingenious contrivances for improving the form of the cod-end of the trawl-net exhibited in the Fisheries Exhibition. First, there is the plan invented and patented by Mr. G. Read, of Deal, Fig. 10 among our illustrations. The method adopted in this case is to attach to the extremity of the trawl-net a circular flue or passage of a given length, covered with a net having large square meshes and extended by several hoops of wood. The drag on the tapered end of the ordinary trawl-net causes the meshes to lose their width of opening, and become diamond shaped, and eventually close up altogether; the immature fish must therefore be destroyed by the pressure of other fish and of the dross, to which they are exposed. Mr. Read's circular flue-net, with its large square meshes being the terminus of the end of the trawl-net allows the immature fish to avoid the crush behind, and get into it, from which they at once escape through its wide meshes, these being always open and retaining their shape, however great is the drag on the net. It also affords special facilities for discharging the take of fish on to the deck of the vessel, while the trawl beam is alongside. Figure 8 shows another method of effecting the same object. It is the invention of Mr. G. W. Morris, of Lowestoft. In this there is a flue net extended by circular wooden hoops, as in Mr. Read's net; but instead of the enlarged net with square meshes Mr. Morris used metal rings linked together, and so forming a metallic net. The inventor considers that the chance for the immature fish to escape is greater through metal rings than by any description of net made of twine. Mr. G. G. Schrieber, of Lowestoft, also exhibits an invention for preserving the immature fish; he uses an elastic material, which forms openings through which the small fish escape.—*Illustrated London News.*



1. Lobster pots. 2. Sprat fishing with stow-net. 3. The net and gear under water. 4. Trawl-beam carriage. 5. Harpoon, fluking, and eel spears; cod lines, scull, bowls, and sinkers. 6. Live bait corve. 7. Cod-hook. 8 and 10. Improved trawl-net pockets, allowing immature fish to escape. 9. Ground creeper. 11. Improved dredge.

THE INTERNATIONAL FISHERIES EXHIBITION: ARTICLES OF FISHING GEAR.

EVOLUTION OF CONDUCT.

WHAT says the doctrine of evolution with regard to the ethical side of this twofold assertion that lies at the bottom of all religion? Though we cannot fathom the nature of the inscrutable Power that animates the world, we know, nevertheless, a great many things that it does. Is there a divine sanction for holiness and a divine condemnation for sin? Are the principles of right living really connected with the intimate constitution of the universe? If the answer of science to these questions be affirmative, then the agreement with religion is complete, both on the speculative and on the practical sides; and that phantom which has been the abiding terror of timid and superficial minds—that phantom of the hostility between religion and science—is exorcised now and for ever. Now, science began to return a decisively affirmative answer to such questions as these, when it began, with Mr. Spencer, to explain moral beliefs and moral sentiments as products of evolution. For clearly, when you say of a moral belief or a moral sentiment that it is a product of evolution, you imply that it is something which the universe through untold ages has been laboring to bring forth, and you ascribe to it a value proportionate to the enormous effort that it has cost to produce it. Still more, when with Mr. Spencer we study the principles of right living as part and parcel of the whole doctrine of the development of life upon the earth; when we see that, in ultimate analysis, that is right which tends to enhance fullness of life, and that is wrong which tends to detract from fullness of life—we then see that the distinction between right and wrong is rooted in the deepest foundations of the universe; we see that the very same forces, subtle and exquisite and profound, which brought upon the scene the primal germs of life and caused them to unfold, which through countless ages of struggle and death have cherished the life that could live more perfectly and destroyed the life that could only live less perfectly, until humanity, with all its hopes and fears and aspirations, has come into being as the crown of all this stupendous work—we see that these very same subtle and exquisite forces have wrought into the very fibers of the universe those principles of right livin which it is man's highest function to put into practice. The theoretical sanction thus given to right living is incomparably the most powerful that has ever been assigned in any philosophy of ethics. Human responsibility is made more strict and solemn than ever, when the eternal Power that lives in every event of the universe is thus seen to be in the deepest possible sense the author of the moral law that should guide our lives, and in obedience to which lies our only guarantee of the happiness which is incorruptible—which neither inevitable misfortune nor unmerited obloquy can even take away.—*John Fiske, in Knowledge.*

THE ANTIQUITY OF MAN.*

By W. PENGELLY.

PREVIOUS to 1858 all geological evidence respecting the antiquity of man was received with apathy and indifference. Early in the present century the Rev. J. M'Enery discovered flint implements beneath a thick continuous sheet of stalagmite in Kent's Cavern, Torquay; but when he submitted these specimens to Dr. Buckland, then the leading geologist of the day, the latter refused to regard them as evidences of the antiquity of man, but was of opinion they belonged to the ancient Britons, who "had scooped out ovens in the stalagmite," thus accounting for their presence in the diluvium. This opinion Dr. Buckland held, notwithstanding Mr. M'Enery's statement that in no instance had he discovered evidence of breaches or ovens in the floor, but one continuous plate of stalagmite diffused uniformly over the loam. In justification of Dr. Buckland's conduct, it should be mentioned that he himself had explored Kent's Cavern previous to Mr. M'Enery's researches therein, and, while doing so, had discovered a flint implement. This, however, he found under such circumstances as did not conflict with his published opinion on the low antiquity of man.

But is doubtful whether even Dr. Buckland's faith in his early convictions remained unshaken to the end, for when pressed by an intimate friend, a professor at Oxford, to prepare a new edition of his "Reliquæ Diluvianæ" and his "Bridgewater Treatise," he excused himself on the ground that the work would not be editing "but rewriting."

In 1840 Mr. Godwin Austen, F.G.S., read a paper before the Geological Society of London on the bone caves of Devonshire. Speaking of Kent's Cavern, Mr. Austin said that human remains and works of art, such as arrow heads and knives of flint, occurred in all parts of the cave, and throughout the entire thickness of the clay, and no distinction founded on condition, distribution, or relative position could be observed, whereby the human could be separated from the *reliquæ*. He also expressed the opinion that the bones and works of art must have been introduced into the cave before the flooring of stalagmite had been formed. These statements, however, attracted little or no attention at the time.

In 1846 the Torquay Natural History Society appointed a committee, consisting of Dr. Battersby, Mr. Vivian, and Mr. Pengelly to make a few diggings in Kent's Cavern for the purpose of obtaining specimens for their museum. In the report of their investigations this committee stated that they had established the important point that relics of human art were found beneath this unbroken floor of stalagmite. After taking every precaution by sweeping the surface and examining most minutely whether there were any traces of the floor having been previously disturbed, they broke through the solid stalagmite in three different parts of the cavern, and in each instance found flint knives. In the spot where the most highly finished specimen was found, the passage was so low that it was extremely difficult with quarrymen's tools and good workmen to break through the crust, so that the supposition that it had been previously disturbed wass impossible. But such was the incredulity with which the inferences deducible from these facts were received, that when the report was printed in the *Quarterly Journal* of the Geological Society, it was formally announced that the authors alone were responsible for the facts and opinions contained in their respective papers.

This state of incredulity and apathy lasted until 1858, when some workmen engaged in a limestone quarry on Windmill-hill, near the fishing town of Brixam, in South Devon, unexpectedly broke a hole through what proved to be the roof of an unknown and unsuspected cavern. A committee of exploration was immediately appointed and placed under the superintendence of Professor Prestwich and Mr. Pengelly. The facts which mainly contributed to the decision to have this cave systematically explored were that it was a virgin cave which had been hermetically sealed during an incalculably long period, the last previous event in its history being the introduction of a reindeer antler found attached to the upper surface of the stalagmite floor, and therefore it was free from the objection sometimes urged against Kent's Cavern—namely, that, having been known from time immemorial, and up to 1825 always open to all comers, it had perhaps been ransacked again and again; secondly, it was believed and proved to be a comparatively small cavern, so that its complete exploration was not likely to require a large expenditure of time or money.

At the end of a period of twelve months, during which time the cave had been subjected to a thorough and searching investigation, the committee were able to report that eight flint tools had been found in various parts of the cavern, all of them inosculating with bones of mammalia, at depths varying from nine to forty-two inches in the cave earth, on which lay a sheet of stalagmite from three to eight inches thick, and having within it and on it relics of lion, hyena, bear, mammoth, rhinoceros, and reindeer.

The results of these explorations at Brixham had an enormous influence in impressing the scientific world generally with the value and importance of the geological evidence of man's antiquity.

Among the first fruits of the awakening was a paper by Professor Prestwich, read to the Royal Society, May 26, 1859, on the occurrence of flint implements associated with the remains of animal of extinct species in beds of a late geological period in France at Amiens and Abbeville, and in England at Hoxne. In this paper Professor Prestwich distinctly stated that it was the discoveries which he had witnessed at Brixham which first fully impressed him with the validity of the doubts thrown upon the previously prevailing opinions with respect to such remains in caves. Sir Charles Lyell, too, in his address to the Geological Section of the British Association at Aberdeen, September, 1859, stated that the facts brought to light in connection with the explorations in the Brixham Cave had prepared geologists to admit that skepticism in regard to the cave evidence in favor of the antiquity of man had been pushed to an extreme.

But probably the greatest proof of the change of opinion which began to take place in the scientific world in regard to this subject was that no less than three editions of Sir Charles Lyell's bulky work on the "Antiquity of Man," which first appeared in February, 1863, were published in the course of ten months.

The result of the researches at Brixham quickened a desire to re-examine the Kent's Cavern evidence, and accordingly, in 1864, a committee was formed, and received a grant of money from the British Association for that purpose. The investigation was begun on March 28, 1865. The committee was annually reappointed, and the work continued without intermission to June 19, 1880. The total money grants amounted to £1,900 together with £63 received from various private sources.

In M'Enery's work was a diagram of three remarkable canine teeth, belonging to a group of carnivora to which in 1846 Professor Owen gave the name of *Machairodus latidens*. A considerable amount of skepticism existed for many years as to whether these specimens were really found in Kent's Cavern, it being contended that, from its zoological affinities, *Machairodus latidens* must have belonged to an earlier fauna than that represented by the ordinary cave mammals. It was therefore naturally hoped that the re-exploration of the cavern would set this question at rest.

However, it was not until after the lapse of seven years and four months that the President, while engaged in washing a "find," discovered a well-marked incisor of *Machairodus latidens* with a left ramus of lower jaw of bear, in which was one molar tooth. This at once established M'Enery's accuracy, left no doubt that *Machairodus latidens* was a member of the cave earth fauna—whatever the zoological affinities might say to the contrary—and proved that man and *Machairodus* were contemporaries in Devonshire.

When their exploration began, and for some time afterward, the committee had no reason to suspect that the cavern contained anything older than cave earth. At the end of the first five months, however, facts pointing apparently to earlier deposits began to present themselves, and when, after the expiration of three years, a vertical section was cut, there was shown in clear, undisturbed succession, not only the cave earth with the granular stalagmite lying on it, but under, and apparently supporting the cave earth, another thicker and continuous sheet of stalagmite called crystalline, and below this, again, an older detrital accumulation known as the Breccia, made up of materials utterly unlike those of cave earth. The Breccia was just as rich as the cave earth in osseous remains, but the lists of species represented by the two deposits were very different. The remains of the hyena prevailed numerically very far above those of any other mammal in the cave earth, his presence being attested by his teeth-marks on a vast number of bones, by lower jaws—including those of his own kith and kin—of which he had eaten off the lower borders as well as the condyles, by long bones broken obliquely just as hyenas of the present day break them, and by surprising quantities of his coprolites. In the Breccia, however, there was not a single indication of his presence, the crowd of bones and teeth belonging almost entirely to bears. No trace of man was found in the Breccia until March, 1870, when a flint flake was met with in the third-foot level, which was believed to be not only a tool, but to bear evidence of having been used as such. Two massive flint implements were discovered in the same deposit in May, 1872.

At various times other tools were found, until at the close of the exploration the Breccia had yielded upward of seventy implements of flint and chert. All the stone tools, both of cave earth and Breccia, where Palæolithic, and were found inosculating with the remains of extinct mammals, but a cursory inspection showed them to belong to two distinct categories. Those found in the Breccia, the more ancient series, were formed by chipping a flint nodule or pebble into a tool, while those from the cave earth were formed by first detaching a suitable flake from the nodule, or pebble, and then trimming the flake—not the nodule—into a tool.

The fact, however, most significant of time and physical change was the presence of the hyena in the cave earth or less ancient, but not in the Breccia or more ancient of the two deposits. This fact rendered it almost impossible to avoid the conclusion that the hyena was not an occupant of Britain during the earlier period. The acceptance of such a belief, however, would necessitate the adoption of the view that man was resident in Britain long before the hyena, and also that it was possible for the hyena to reach Britain some time between the deposition of the Breccia and the deposition of the cave earth. In other words, that Britain was part of the continent during this interval.

In support of this argument, it is to be remembered that Sir Charles Lyell recognized the following geographical changes within the British area between the newer Pliocene and historical times—first, a pre-glacial continental period, toward the close of which the Forest of Cromer flourished and the climate was somewhat milder than at present; secondly, a period of submergence, when the land north of the Thames and Bristol Channel and that of Ireland was reduced to an archipelago. This was part of the glacial age, when icebergs floated in our waters. Thirdly, a second continental period, when there were glaciers in the higher mountains of Scotland and Wales. Fourthly, the breaking up of the land through submergence and a gradual change of temperature, resulting in the present geographical and climatal conditions.

The fact that neither in the Kent's Cavern Breccia nor in the Forest of Cromer were any remains of hyena found, and that the list of mammalian remains found in the one does not clash with those found in the other, renders legitimate the inferences that the hyena did not reach Britain until its last continental period, and that the men who made the Palæolithic nodule tools found in the oldest-known deposit in Kent's Cavern arrived either during the previous great submergence, or, what is more probable, unless they were navigators, during the first continental period. There was little doubt, therefore, but that the earliest Devonians were either of glacial or pre-glacial age. Of course, the discovery of remains of hyena in the forest bed of Cromer, or any other contemporary deposit, would be fatal to the argument, but it would leave intact all other evidence in support of the doctrine of British glacial or pre-glacial man.

* Abstract of an address delivered at the British Association.

SACCHARIFYING POWER OF THE SALIVA.

M. A. BECHAMP, in an article contributed to the first number of Brown-Sequard's *Archives de Physiologie* for the present year, after commenting upon the circumstance, at one time considered remarkable, that while the saliva of man possesses the power of converting starch into sugar, no such power is exerted by the saliva of the horse, dog, or ox, undertakes to show—first that human buccal saliva is not indebted for its diastatic power to any alteration effected by the air on the various immediate organic principles which are secreted by the glands and discharged into the buccal cavity; secondly, that the power of converting starch into sugar belongs to a peculiar and special zymase which is contained in the saliva, and that this zymase is the outcome of the action of the microzymes proper to the salivary glands, of the microzymes of the anatomical elements which line the buccal cavity and the tongue, and of the microzymes and infusory animalcules that accumulate in the interstices of the teeth. Lastly, that the parotidean saliva of the horse and that of the dog do not saccharify boiled starch naturally, but that they acquire this power when they are placed in contact with the buccal organisms of man. In the course of these experiments he found the buccal infusory animalcules to have an extraordinary power of converting starch into sugar, one-thousandth part of a gramme of the matter adherent to the free border of the gums of a healthy man, after being frequently washed with a weak solution of creosote, acting powerfully on starch paste. This material was formed of the debris of epithelial cells, of numerous molecular granules, and of many moving or stationary short or long bacteria (probably segments of *Leptothrix buccalis*), and no doubt some remains of food. The buccal organisms or granules are the bodies he endeavors to show are the really active bodies, for he has accomplished the removal of the other elements, and found the saliva of man still to retain its powers, and he supplies evidence to show that they are not identical with the bodies which develop in the saliva either of man or of the animals named after removal from the body and filtration.—*Lancet.*

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